NARA
Northwest Advanced Renewables Alliance

Newsletter | **January 2014**
Volume 3.1

# Variations of Forest Residual Biomass

Thinning and harvesting forests in the Pacific Northwest generate lots of residual woody biomass. Currently, much of that biomass is left in slash piles while a small percentage is used to heat buildings or generate electricity. By law, those slash piles left unused are burned to reduce forest fire hazard. This process contributes to smoke and air pollution. NARA is helping to develop an industry that converts this unused wood material into chemicals like isobutanol.

As an industrial feedstock, forest residues are quite variable. Factors that influence the quality of this potential feedstock are the species mix, residue age, moisture content, harvest method, as well as the amount of dirt, rocks and trash mixed with the wood. As demand for forest residuals increases and diversifies, the market will require new grade classifications and standards for these forest residues. In fact, according to a recently published paper *Characteristics of Forest-Derived Woody Biomass Collected and Processed in Oregon* draft standards for solid biofuels are being developed by the International Organization of Standardization (ISO) and the American Society of Agricultural and Biological Engineers (ASABE) to serve the future markets.

NARA researcher and Feedstocks Logistics Team Leader John Sessions is a co-author of this research aimed at assisting both the ISO and ASABE efforts to classify solid biomass fuels. This NARA effort measures vital quality characteristics of forest- residuals, such as moisture content, particle size distribution, bulk and energy density, and noncombustible ash content. In this study, 55 forest residual biomass samples, processed in the field for energy production, from 34 harvest sites in Oregon were collected over a two-year period. Roughly two-thirds of the samples were collected from western Oregon and contain predominantly Douglas-fir residuals. A third of the samples (19 of 55) were collected in eastern Oregon containing predominately pine and juniper species. The information obtained from this study suggests that characteristics of forest wood residuals remaining after commercial harvest differ widely. Here is a summary of their important findings.

## Moisture Content

Moisture content is important because it can have a significant effect on residue transport costs due to weight considerations. In addition, wood biomass with high moisture content does not burn efficiently and is less attractive for boiler use than dry biomass. In this study, moisture content (wet basis) for the 55 samples averaged 40% but was found to range from 12 to 66%. This range is strongly influenced by the collection period; dry or rainy

## Particle Distribution

Particle size distribution within each sample was determined by sorting through a two of screen sizes; 50 mm (2-in.) and 10 mm (3/8-in) round hole sizes. Screened samples were separated into three fractions: large particles retained on the top screen (overs), material in between screens (mids) and those that fell through the lower screen (fines). On average, 5% of the particles ended up as overs and 25% percent were fines; thus leaving 70% as mids.

Particle variation among the samples was significant. The maximum percentage of overs, mids and fines was 12, 98 and 94 respectively; whereas the minimum was 0, 6 and 2. In general, fines contain much of the bark, needles and contaminants (dirt and rocks). For conversion to isobutanol, fines are not an attractive feedstock due to their relatively high ash and low carbohydrate content (see earlier newsletter story). In addition, the authors point out that the particle size distribution can impact processing and handling characteristics at the point of use particularly for energy producers.

## Non-Combustibles (ash)

The samples contained noncombustible (ash) content as high as 26.7 (% of dry weight). The lowest ash content detected was 0.3% with an average ash content of 6%. Ash content in the fines was also assessed. On average, ash content in the fines was 14.1 %. Since the ash content of softwoods is typically under 1%, these findings indicate that the majority of samples contained contaminants such as dirt and rocks.

## Heating Value And Bulk Density

Energy density values for the samples were determined under two classifications: low heating value (LHV) was determined from green samples and high heating value (HHV) was from oven-dried samples. Energy density values varied with a maximum of 16.8 (MJ/kg) and 21.6 and a minimum of 5.0 and 11.5 for the LHV and HHV samples respectively. Lower values associated with the green samples can be attributed to moisture content.

Bulk density was measured for wet and dried samples. Maximum range for wet samples was 432 (kg/m3) and the minimum was 108. Maximum range for dried samples was 224 and the minimum was 72. Bulk density can have a substantial effect on transport costs as described in an earlier paper co-authored by Dr. Sessions are summarized here.

## Management Implications

The variability shown in the measurements reflect the variability of woody biomass feedstock from forest operations available in today's marketplace. The authors offer some options forest contractors can consider to reduce feedstock variability. For instance, an economical method to reduce wood biomass moisture is to field dry the residues. Field drying also allows needles to drop, which would lower ash and fines content.

The authors observed that residual samples contained far less ash if they were pre sorted and kept relatively clean by chipping operators. In the paper, they state:

*…noncombustible contamination content can be managed by avoiding pushing piles together with tractors, running over piles with skidders, or trying to fully recover piles by scratching in the dirt. (p. 526)*

In addition, the type of machinery used can improve feedstock quality. The authors point out that chippers or mill hogs produced a lower percentage of "overs" and consequently a feedstock with higher bulk density than feedstock produced from horizontal and tub grinders.

## In Conclusion

Offering solutions, however, was not the paper's intent. Below are concluding remarks in the text:

*The reader should note that this study was not designed to test interactions with process variables that might influence these quality characteristics. Our purpose was simply to generate information on what is currently occurring in the commercial marketplace. We note that the large variations observed in particle size distribution, bulk density, moisture content, and noncombustible ash are signs of an evolving industry. Development of residue classification systems, expanding markets, and continuing equipment development may markedly change the characteristics of tomorrow's woody biomass derived from western forests. Future steps including structured tests of interactions between process variables and quality characteristics will be useful to inform managers on the costs and methods for reaching solid biomass fuel specifications.*

# Co-Product Development: Lignin-Rich Material to Clean the Atmosphere

Researchers at Weyerhaeuser are finding ways to make valuable products from the lignin-rich material leftover after slash piles have been converted to biojet fuel. Finding commercial uses for this material is an essential part of producing economically competitive biojet fuel. One promising product generated from this lignin-rich material is activated carbon. Activated carbon is derived from any organic substance with high carbon content such as coal. Its structure contains numerous cavities and pores that help trap impurities and environmental contaminants in water and air.

Turns out that the activated carbon made from this lignin-rich material adsorbs mercury nearly as well as commercially available products. Weyerhaeuser researchers Ian Dallmeyer, Carter Fox and David Fish recently made activated carbon from the wood material produced by various conversion methods being explored by NARA. When the mercury adsorption of these activated carbon products was compared to commercially available products, they found similar properties. There are a number of ways to influence the porosity of activated carbon, and efforts are currently underway to enhance mercury adsorption of these new activated carbon materials.

## Mercury Pollution

Mercury pollution is a big deal. Mercury in the air enters water and soils, is converted into methylmercury, and moves up the food chain. Methylmercury exposure is toxic to wildlife and humans. In December, 2012, the U.S. Environmental Protection Agency (EPA) finalized changes to the Clean Air Act that require boilers and some incinerators to reduce the amount of air pollutants, including mercury, emitted into the atmosphere. To comply with these regulations, materials like activated carbon are in high demand. According to Transparency Market Research, "global market for activated carbon was valued at USD 1,913.2 million in 2012 and is expected to reach USD 4,180.5 million by 2019".

## Finding Value In Co-Products

According to NARA's most recent economic analysis, biojet fuel produced from forest residuals is more expensive to produce than petroleum-based jet fuel when a brand new facility is built from the ground up. The lignin-rich material leftover from the conversion process could be burned to produce electricity and heat, but higher value products may be the key to improving the price of biofuels. Because there is no preprocessing required to convert the lignin-rich residual into activated carbon, the cost of production maybe well under the current commercial selling price. "Given the economic assessment, market factors, and the maturity of technology for producing activated carbon, it is not unreasonable to suggest that co-production of activated carbon in conjunction with biofuel is a feasible and potentially lucrative strategy to implementing a commercial scale biorefinery", says David Fish.

## Additional Products

The NARA co-products team is working on many fronts to discover additional products from the lignin-rich material. In addition to activated carbon, other potential products being developed include a replacement for carbon black in rubber products, an anti-oxidant for asphalt and a viscosity modifier for cement.

Some researchers on the team target products made from a purified lignin source, which means that they must first separate the lignin from the other leftover materials such as unused carbohydrates, yeast bodies and ash. Work by NARA researchers Jinwen Zhang and Michael Wolcott at Washington State University are exploring ways to convert lignin into smaller molecules that can be used to make a variety of products (see earlier story). NARA researcher Simo Sarkanen, at the University of Minnesota, is finding ways to convert lignin into plastics and thermal insulation products.

Forest near Breckenridge, CO with substantial-beetle killed trees

# Bioenergy Alliance Network of the Rockies (BANR)

On November 6th 2013, the US Department of Agriculture awarded nearly $10 million to fund research to develop renewable fuel and biochar production using insect-killed trees in the Rocky Mountain region as a sustainable feedstock. The award was provided to the Bioenergy Alliance of the Rockies (BANR): a consortium of academic, industry and government organizations led by Colorado State University.

BANR's website can be found here.

The USDA press release announcing BANR can be found here.

BANR is the most recent Coordinated Agricultural Project (CAP) funded within the Sustainable Bioenergy challenge area by the USDA National Institute of Food and Agriculture (NIFA) Agriculture and Food Research Initiative (AFRI). They are one of seven AFRI-CAP projects, including NARA, funded since 2011.

The regions served by NARA and BANR overlap in western Montana and Northern Idaho. To date, NARA leadership has met with BANR members and began the process of identifying efforts where the two organizations can share information and resources to accomplish the project goals.

" We are still working out the details, but there will definitely be strong coordination between BANR and NARA", says Michael Wolcott, NARA co-project director. "This coordination is very important to the USDA, our stakeholders, and to the success of both projects. We are very excited to have this opportunity to work with this strong team on issues of mutual interest to ourselves and our shared stakeholders."

One significant distinction between the two projects is that BANR will explore the use of a thermochemical process called pyrolysis to convert insect-killed trees into biofuels and biochar; whereas, the NARA project is developing a biochemical conversion process which relies on yeast to convert sugars, produced from forest residuals, into biofuels. In contrast, the process relies on heat and pressure to convert the wood material into fuels. BANR has partnered with Cool Planet Energy Systems, whose mobile pyrolysis process can be tailored to the beetle-kill feedstock in a specific area. This approach utilizes mobile conversion facilities that move into a centralized location for the duration of a forest treatment. This system is not small enough to fit at a logging site, but would locate in a central area close to utilities and transportation. The temporary siting differs from the stationary conversion concept developed by NARA, but is similar to depot sites currently under study.

Additional BANR partners include the University of Idaho, University of Montana, Montana State University, the University of Wyoming, U.S. Forest Service Rocky Mountain Research Station and the National Renewable Energy Lab.

NARA is led by Washington State University and supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.