Forest residuals used in grinding tests. From left to right: branches and tops, pulpwood, butt-log-chunks. Images courtesy of Rene Zamora-Cristales, Oregon State University.

Structured tests for grinder configurations

Forest residuals (tree limbs, branches, small trees and unusable trunk bits) come in all different sizes. Before they can be efficiently transported to and processed at a conversion facility for biofuels and co-products, they need to be ground up into small pieces.

To break up the wood material, a diesel-powered grinder is typically used. This machinery forces the forest residual material past bits mounted on a cutting rotor. The bits hammer or cut the wood material into smaller pieces, which are then passed through screens that separate the wood grindings based on size. The choice of bits and screens used can affect the bulk density and particle size distribution of the reduced product. A higher bulk density translates into more forest residual material per truckload, and the particle size distribution can be an important quality characteristic depending on the user.

To help wood processors understand how grinder bit and screen configurations impact forest residual processing and costs, structured tests were performed and funded by the USDA-NIFA (through NARA), and the results were recently published in the Biomass and Bioenergy Journal.

> Read Effect of grinder configuration on forest biomass bulk density, particle size distribution and fuel consumption here.

Structured tests

This is the first peer-review study to isolate the effects of grinder bit types and screen sizes on particle distribution, bulk density, bark content and fuel cost when processing forest residuals. The authors evaluated the impact of two bit types (carbide-hammer and knife-edge) and three screen sizes on particle size distribution, bulk density and fuel consumption from three feedstock size classes: branches-and-tops, pulpwood, and butt-log-chunks. These feedstock size classes had a moisture content of 15.3%, 24.8%, and 26.3 % respectively. The screen size combinations tested were small (2-3 inches), medium (3-4 inches) and large (4-5 inches). The tests consisted of six treatments - knife–edge bits plus a small, medium, or large screen and carbide–hammer bits plus small, medium, or large screen. Each of these treatments were applied to the three feedstock size classes.

The study used approximately 180 tonnes of Douglas-fir forest residuals generated after timber harvest, four months prior, in western Oregon.

Results

Bulk density

When grinding branches-and-tops, the screen size and bit type selected had little impact on bulk density for the final product. Bit type and screen size did, however, impact the bulk density of grindings derived from pulpwood and butt-log-chunk size classes. In this case, using knife-edge bits and smaller screen sizes provided grindings with the highest bulk density for these two feedstock classes. Knife-edge bits produced grindings that were 16% denser that those produced using carbide-hammer bits. The use of small screens with carbide-hammer or knife-edge bits increase bulk density by 16% and 9% respectively compared to using large screens.

The bulk density of grindings from the three size classes differed with the branches-and-tops grindings reporting the highest bulk density levels.

Particle size distribution

Screen size and bit type impacted particle size distribution for the branches-and-tops plus pulpwood size classes but not the butt-log-chunk size class. Knife-edge bits and smaller screen sizes produced a higher percentage of fine particles. The authors speculate that the increased screen-residual contact provided by smaller screens contributed to producing finer particles. Large screens produced a greater amount of large particles.

Fuel Consumption

Grinder fuel consumption increased as forest residual feedstock size increased; for instance, grinding branches-and-tops sized feedstock consumed 2.1 L t-1 less fuel than for grinding pulpwood and 3.3 L t-1 less fuel that grinding butt-log chunks. Smaller screen size use resulted in higher fuel consumption. For pulpwood and butt-log-chunks size classes, the use of knife-edge bits reduced fuel consumption compared to carbide-hammer bits.

Bark and non-wood substances

The branches-and-tops size class contained 7.5% and 7.9% more bark and other substances than the pulpwood and butt-log-chunks size classes respectfully. The authors point out that the higher surface-volume ratio afforded by the branches-and-tops would partially account for the increased bark and non-wood substance content. The choice of bit type or screen size did not significantly affect bark or non-wood substance content in the grindings.

Conclusions

The results show that the efficiencies attributed to the choice of screens and bits are dependent on the forest residual size class. The authors point out that knife-edge bits wear more quickly that carbide-hammer bits and that bit replacement costs would need to be considered.

The information provided in the study is being used to develop a techno-economic analysis and life cycle assessment for the conversion of forest residuals into biojet fuel and co-products. The information is also intended to provide wood processors science-based information to help increase efficiencies and improve the economics of processing forest residuals for transport.

Image courtesy of Alaska Airlines

Using northwest forest residuals to power a commercial flight

The Northwest Advanced Renewables Alliance is producing 1,000 gallons of iso-paraffinic kerosene to be blended and used in a demonstration flight anticipated in Spring 2016. This event, when completed, will represent the first commercial flight using alternative jet fuel made from forest residuals.

The development and use of alternative jet fuel made from forest residuals provides an educational opportunity for all stakeholders in the supply chain on how forest residuals (slash piles) can be used to offset fossil fuel use and help strengthen wood-based economies.

NARA partners with Alaska Airlines

Recently, Alaska Airlines announced a partnership with NARA to use the alternative jet fuel for a commercial flight. This partnership is not only ideal from the perspective that Alaska Airlines is a Pacific Northwest-based airline using alternative jet fuel made from forest residuals sourced in the northwest, but also because Alaska Airlines was the first U.S. airline to fly multiple commercial passenger flights using a biofuel refined from cooking oil and has demonstrated its commitment to support sustainable biofuel development. Details regarding the fuel blend parameters, flight date and route have not been announced.

Regional forest owners provide forest residuals

Approximately 180 bone-dried tons of ground Douglas-fir forest residual material was transported to Lane Forest Products near Eugene, Oregon to serve as the feedstock for producing the 1,000 gallons of iso-paraffinic kerosene. This material was sourced from multiple areas in the NARA region. Weyerhaeuser, a NARA affiliate member, supplied forest residuals from their forestland in southern Oregon. The Confederated Salish and Kootenai Tribes and the Muckleshoot Tribe also provided forest residuals from their forests in western Montana and western Washington respectively. The forest residuals were mixed and screened and currently await transport to a pretreatment facility. Samples of the forest residuals were collected and will be later characterized for ash, lignin and carbohydrate properties.

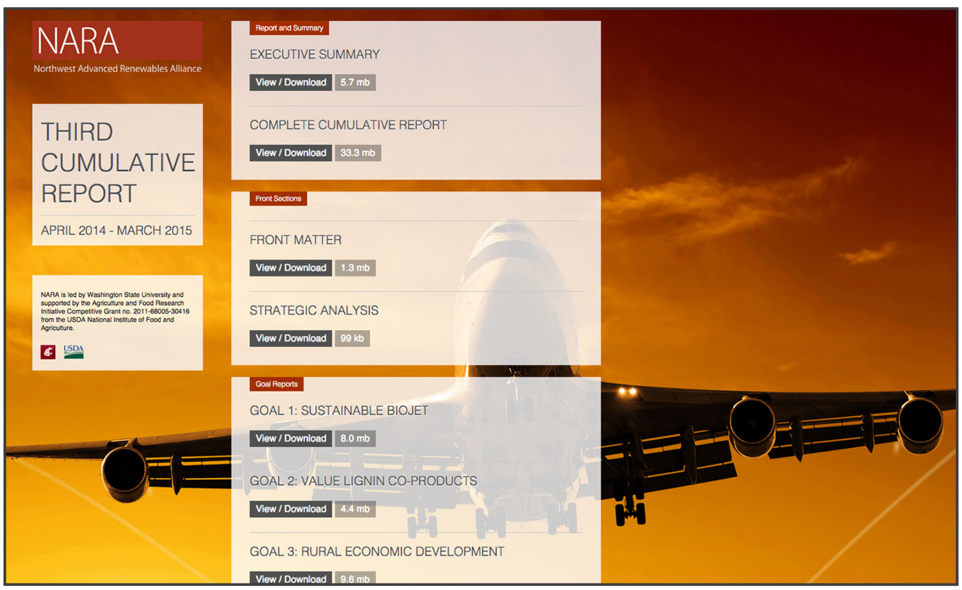
Gevo, Inc. provides technology to produce bio-jet fuel from simple sugars

Gevo, a NARA affiliate member, will use its patented technologies to convert the cellulosic sugars from the forest residuals into biojet fuel. The first step in this process will convert the cellulosic sugars from wood into renewable isobutanol. Gevo has worked with NARA to adapt its patented Gevo Integrated Fermentation Technology® (GIFT®) to accommodate wood sugars. Gevo will perform the fermentation process at a demonstration facility in St. Joseph, Missouri, which is jointly owned by Gevo and ICM Inc. Next, Gevo will use its patented hydrocarbon technology to convert the isobutanol into an alcohol-to-jet-synthetic paraffinic kerosene (ATJ-SPK) fuel. This process will be completed at a demonstration facility in Silsbee, Texas, which is co-operated with South Hampton Resources. Gevo recently announced their intention to participate in the NARA 1,000 gallon biojet fuel project using forest residuals and also recently announced their partnership with Alaska Airlines to supply alcohol-to-jet biofuel.

Additional partners to be announced later

NARA is negotiating with a number of potential facilities that can accommodate the steps required to pretreat and hydrolyze the wood residuals into simple sugars at scale. NARA will use a sulfite-based pretreatment process that is designed to accommodate existing pulp mill infrastructure.

NARA anticipates that the alternative jet fuel will be produced and certified by the end of 2015. The production process will provide valuable scale-up information and process validation to NARA researchers and stakeholders. The demonstration flight bridges NARA research with the targeted goals of using forest residuals to supplement fossil fuel use and improve rural wood-based economies.



Webpage for the NARA 2014-2015 Cumulative Report

NARA's Cumulative Report is available

NARA's third Cumulative Report is now available online. The report describes research efforts and activities conducted during April 2014 to March 2015.

> View the NARA Cumulative Report: April 2013 - March 2014 here.

Cumulative Report content

The report is segmented into sections that relate to NARA's five goals: Sustainable Biojet, Value Lignin Co-Products, Rural Economic Development, Supply Chain Coalitions, and Bioenergy Literacy. Each section contains an executive summary highlighting the major accomplishments.

Topics discussed in this report cover:

- a pretreatment and fermentation process for large-scale biojet fuel production using Douglas-fir residuals;
- biomass availability and logging utilization estimates plus grinding parameters;
- plastic, epoxy and activated carbon produced from Douglas-fir lignosulfonates;
- life cycle assessments (LCA) for biojet fuel and lignin-based co-products;
- biorefinery and depot site selection and design;
- studies evaluating the impact of forest residual removal on soil nutrients, water and wildlife;
- programs to promote bioenergy literacy for students and working professionals.

Future direction

Starting July 2015, the NARA project will enter its fifth and final year. The activities described in the 2015 cumulative report provide the foundation for producing NARA's final project deliverables. These final year deliverables include:

(1) a demonstration of the integrated technology for production of alternative jet fuel through production of 1,000-gallons of iso-paraffinic kerosene (IPK);

(2) a demonstration of the scale feasibility for select co-products;

(3) a final economic, environmental, and social assessments of production models to assess overall sustainability;

(4) stakeholder integration efforts around a commercial flight of the produced alternative jet fuel.

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.