NARA
Northwest Advanced Renewables Alliance

Newsletter | **May 2013**
Volume 2.4

NARA's Corporate Partners

NARA is an alliance of 18 affiliated organizations working together to accomplish the following goals:

1) Develop a sustainable biojet fuel industry in the Pacific Northwest that uses residual woody biomass as feedstock.

2) Create valuable co-products made from lignin, which is an industrial by-product of the woody biomass to biojet process.

3) Enhance and sustain rural economic development

4) Envision pilot supply chains for biofuels and bioproducts within the NARA region

5) Improve bioenergy literacy to develop a future energy workforce and enhance citizen understanding

Three of these affiliated organizations, Gevo, Weyerhaeuser, and Catchlight Energy, are NARA corporate partners providing resources, knowledgeable experience, leadership, and a critical business perspective and commitment to the project. The following newsletter articles provide a brief summary of the contributions provided by these corporate partners.

Gevo

A leading renewable chemicals and advanced biofuels company

Gevo is based in Englewood, Colorado and maintains production facilities and test sites in the United States. Their commercialization efforts focus on converting renewable biological feedstocks into isobutanol, a naturally occurring four-carbon alcohol. Isobutanol is a valuable petro-chemical substitute that can be used to manufacture many products such as solvents, coatings, plastics, and specialty fuels such as biojet fuel. More information about Gevo is available on their website and as well as many articles listed on their news and media page.

Converting wood residue carbohydrates into isobutanol

Gevo, through the leadership of team leader Dr. Andrew Hawkins, is an important contributor to the residual wood to biojet supply chain being developed through the NARA project. After wood fiber is pretreated and the polysaccharides are enzymatically hydrolyzed, simple sugars like glucose are released in solution. Gevo makes use of their proprietary technology GIFT®, Gevo's Integrated Fermentation Technology®, to convert those simple sugars into isobutanol and simultaneously separates the isobutanol from the fermentation broth.

The GIFT® platform relies on specialized yeast to serve as a biological catalyst. The yeast import the glucose and other simple sugars from the wood residue solution into their cell, generate isobutanol from the simple sugars, and then secrete the isobutanol out of their cell and into the solution. As isobutanol accumulates in the solution, it is separated and collected.

Selecting superior yeast strains

As simple as this process description sounds, there are significant challenges. The wood residue solution is a complex mixture of many chemicals including the simple sugars. Some of the chemicals, plus the isobutanol being produced, are

toxic to yeast and can significantly reduce growth and isobutanol output. Gevo researchers are using multiple approaches to address this challenge.

One approach takes advantage of yeast's ability to reproduce rapidly and modify its genetic makeup to adapt to varied environments. As yeast reproduce in the wood residue solution, individual yeast strains are isolated. These individual strains are evaluated for their growth and isobutanol output and their ability to withstand the toxic conditions. Over the course of testing many stains, individual strains emerge as superior to other strains. These superior strains are then selected and the cycle of strain selection and testing continues. Ultimately strains are isolated that can resist the toxic elements and produce isobutanol at a high level.

Another approach to improving isobutanol yields is to evaluate yeast performance on wood residue solution generated from different upstream processes. For instance, Gevo is testing yeast performance on wood residue solutions derived from multiple pretreatment protocols being developed within the NARA project. Feedback between Gevo and pretreatment research may help modify the wood residue solution and make it less toxic to yeast.

Ultimately, Gevo will utilize its proprietary technology to convert the yeast-derived isobutanol into biojet fuel. The initial goal is to produce 1000 gallons of biojet fuel that meets ASTM (American Society for Testing and Materials) specifications as a suitable jet fuel blend stock.

Providing economic insight

A substantial element of the NARA project is to ensure that the wood residue to biojet fuel conversion process is sustainable environmentally, socially and economically. The process engineering team at Gevo has been instrumental in providing unit operation costs for the isobutanol to biojet fuel conversion steps and capital cost estimates for infrastructure development. All of these inputs help establish a basis for a developing techno-economic model used to gage the complete cost of producing biojet fuel from wood residues and insure that the process is economically sustainable.

Weyerhaeuser

Weyerhaeuser

The Weyerhaeuser Company was founded more than 100 years ago with 900,000 acres of timberland, three employees and a small office in Tacoma Washington. Today, Weyerhaeuser owns or manages 20.3 million acres of timberland and employs more than 13,000 people who serve customers worldwide. The company operates four core businesses: timberlands, wood products, cellulose fibers and real estate. As a valued corporate partner with NARA, Weyerhaeuser contributes expertise with key personnel and resources.

Project leadership and management

Linda Beltz, Director of Technology Partnerships for Weyerhaeuser, serves on NARA's executive committee. In addition to providing overall leadership to the project, Dr. Beltz led the implemention a phase-gate process used to provide an overall roadmap of progress and move the project toward success. The four phases applied to the NARA project are 1) feasibility assessment, 2) feasibility validation, 3) scale-up readiness, and 4) commercial options. Each team is assigned critical path milestones targeting accomplishments to be completed before the project can engage in a subsequent phase. The model is an instrumental tool used to coordinate the efforts of multiple teams on multiple objectives and for allocating resources.

Valuable Lignin Co-products

David Fish, Senior Scientist for Weyerhaeuser, applies his thirty-two years of commercial product development experience to contribute to NARA's goal to create valuable co-products from the industrial byproduct of the woody biomass to biojet process. David's team has characterized the lignin-rich byproduct produced from the various pretreatment options and is currently developing and testing this material for use in promising high-value applications.

Sustainability

Weyerhaeuser embraces a broad view of sustainability by setting goals and monitoring progress against targets in three critical areas: performance, people, and planet. For the NARA project, Weyerhaeuser has established a Long-term Soil Productivity Site in southern Willamette Valley of Oregon. This site allows researchers to understand the effects of woody biomass removals and any associated soil compaction on soil sustainability, water quality and wildlife. Weyerhaeuser researchers and NARA members Scott Holub and Greg Johnson and their team provide the expertise used to design the experiments and develop the site. Since this project was described earlier in this newsletter, pre-harvest data has been collected and treatments are being implemented.

Feedstock Sourcing

Gevan Marrs, a senior scientist for Weyerhaeuser, leads NARA's feedstock sourcing effort in the Feedstock Logistics Team and co-leads the development of techno-economic models for the NARA biojet and lignin co-products production chain. The Feedstock Sourcing Team collected, processed, characterized, and distributed large samples of softwood forest residues generated after harvest. Over 500 lbs of each sample were processed. Each sample represents a different feedstock type (softwood species mix, piece size, moisture, etc.) from separate ecoregions in the Pacific Northwest. The samples are fully analyzed and distributed to researchers in the NARA Conversion Team and serve as the baseline standard used to optimize downstream conversion technologies and insure that the data generated on each conversion step is referenced with a specific wood residue type.

The data generated from chipping the various forest residues indicates that bark content and fines can vary considerably between softwood feedstock sources. High bark content and fines lead to lower carbohydrate content and thus biojet yield. Softwood harvesters and handlers can use this information to adjust their practices and minimize bark and fines, balancing harvesting costs with process yields and overall economics.

In addition to processing and distributing the feedstock samples, the Feedstock Sourcing Team completed physical and chemical analyses for each sample providing size distribution, bulk density, polysaccharide, lignin, extractives, and ash characterization. Here again, softwood sources show considerable variability in the chemical components. Researchers and practioners with conversion technologies utilize this information to adjust sourcing and conversion protocols to optimize economics for various feedstock sources.

Techno-Economic Analysis

Gevan Marrs also co-leads the development of techno-economic models for the NARA softwood-to-biojet and co-product production process. The models incorporate capital and operational costs, financial incentives and mass and energy balances from each conversion step. The models serve as a tool to identify steps in the production chain that can lower costs and provide estimates on product economic return. A first-cut model incorporating data of the overall economics has been generated and published results should be presented within this year.

Catchlight Energy

Catchlight Energy LLC is a joint venture between Chevron and Weyerhaeuser. Its objectives are to help commercialize cellulosic biofuels by providing feedstock and offtake services to third-party conversion facilities, develop and license technology and deliver renewable forest-to-fuel transportation products in a manner that is scalable and sustainable — both environmentally and economically. As a member of NARA, Catchlight provides technical expertise and physical assets to the NARA project.

Mild Bisulfite Pretreatment

One of NARA's goals is to generate biojet fuel and valuable co-products from wood residues. Catchlight Energy scientists Dwight Anderson and Johnway Gao are leading a team located at the Catchlight Energy facilities to contribute to the goal. Their team is evaluating a promising pretreatment option called Mild Bisulfite Pretreatment. This process works well on the size of wood chip already used by the pulp and paper industry, which is beneficial because the chips can be processed using existing equipment and with no additional chipping costs.

The parameters of this pretreatment process are being adjusted to minimize production cost and maximize the pretreatment effectiveness, which is measured by how well hydrolyzing enzymes can access the polysaccharides in the wood and release the simple sugars. Once optimized, this pretreatment process will be evaluated at larger scale production rates.

The pretreatment process also produces residual lignin and lignosulfonate. These lignin products are distributed to the NARA Co-products Team as baseline samples for study and ultimate conversion into valued products.

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.