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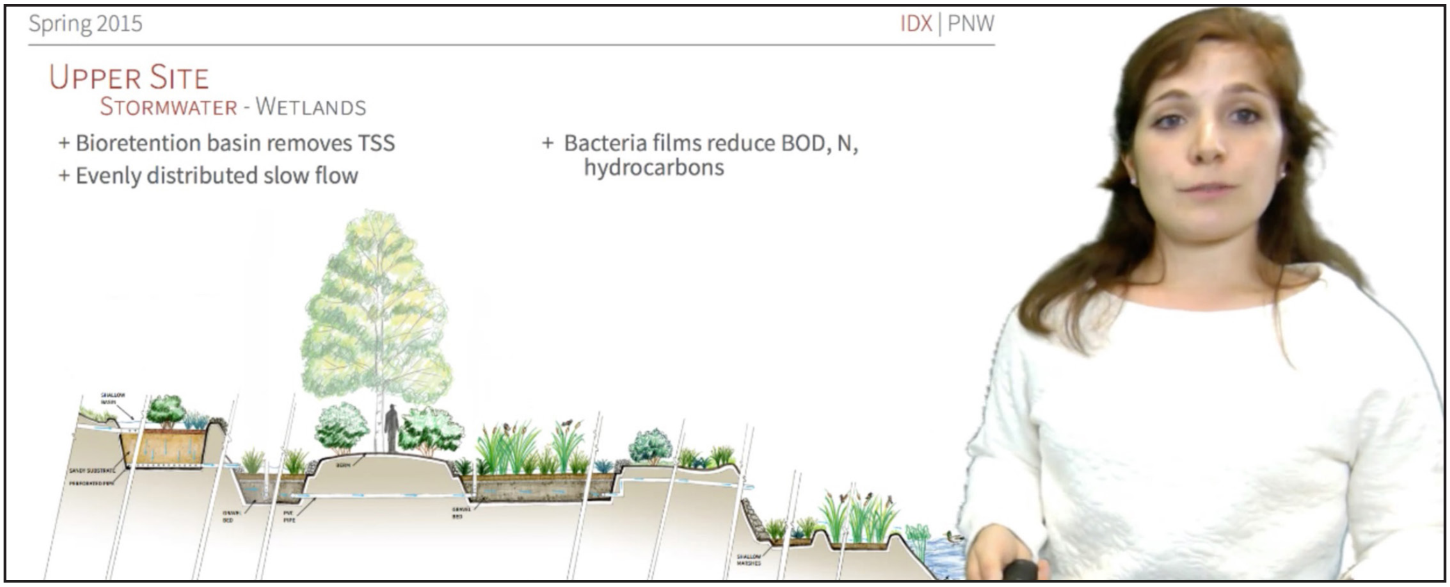


Kate Shrosbree, a landscape architecture student at the University of Idaho, describes wastewater treatment designs.

Students offer sugar depot designs for an existing pulp mill

Turning slash piles into valuable commercial products is an economic challenge; two significant economic hurdles are the cost to process and transport forest residuals and the capital costs needed to build new facilities or retrofit existing ones.

NARA researchers and graduate students associated with the Integrated Design Experience (IDX) course approach this challenge by identifying existing wood processing facilities throughout Idaho, Montana, Oregon and Washington and developing methods to select those facilities that can participate in the supply chain at the lowest cost. In addition, the IDX students provide design options to retrofit existing wood processing facilities, which can in most cases, result in lower capital costs compared to newly built facilities.

Sugar depots are a type of facility that would convert forest residual chips or pellets into simple sugars, which could be concentrated and transported to refineries for conversion into biofuels and other chemical products. Existing pulp mills, which convert wood into paper and lignosulfonates, are ideal candidates to accommodate the role of a sugar depot because much of the infrastructure used to make paper can be also used to produce simple sugars. The addition of simple sugar production capacity could increase a mill's product portfolio and enhance the facility's economic sustainability.

Recently, the IDX course, comprised of WSU civil engineering and University of Idaho landscape architecture students, provided regional stakeholders a webinar where they discussed design considerations for retrofitting an existing pulp mill to produce simple sugars.

> View the IDX webinar Site Design for Liquid Depot here.

Site selection for sugar depot design

Two hundred and fifty potential facility sites were narrowed down to 30 using a mapping approach where assets like biomass availability, port access, social capital, and electricity rates were layered to show "hot spot" regions most suitable for liquid depots. Assets like total acreage, natural gas rates, transportation options, and water treatment facilities were evaluated for the 30 sites and applied weighted scores. From this ranking process, the Georgia Pacific Wauna Paper Mill in northwestern Oregon scored highest as a potential liquid depot, and this site was chosen as a model site for retrofit design concepts and cost estimates.

Site design

The students identified two locations on the property for potential development and described the advantages and disadvantages for each siting option during the webinar. All of the design considerations were based on supporting economic, social and environmental sustainability. For the site design, they considered the topography and existing site layout along with potential constraints such as flood zones, wetlands and soil types.

Key design areas described in the webinar focused on a parking lot expansion designed to handle the additional woody biomass storage and transport, the chemical pretreatment area, transportation flows, and accommodations to handle water runoff in an environmentally sustainable manner. For water flow and treatment designs, they incorporated the use of wetlands, sedimentation basins and bio-retention ponds.

The cost for a sugar depot retrofit was estimated at 281 million dollars based on their designs.

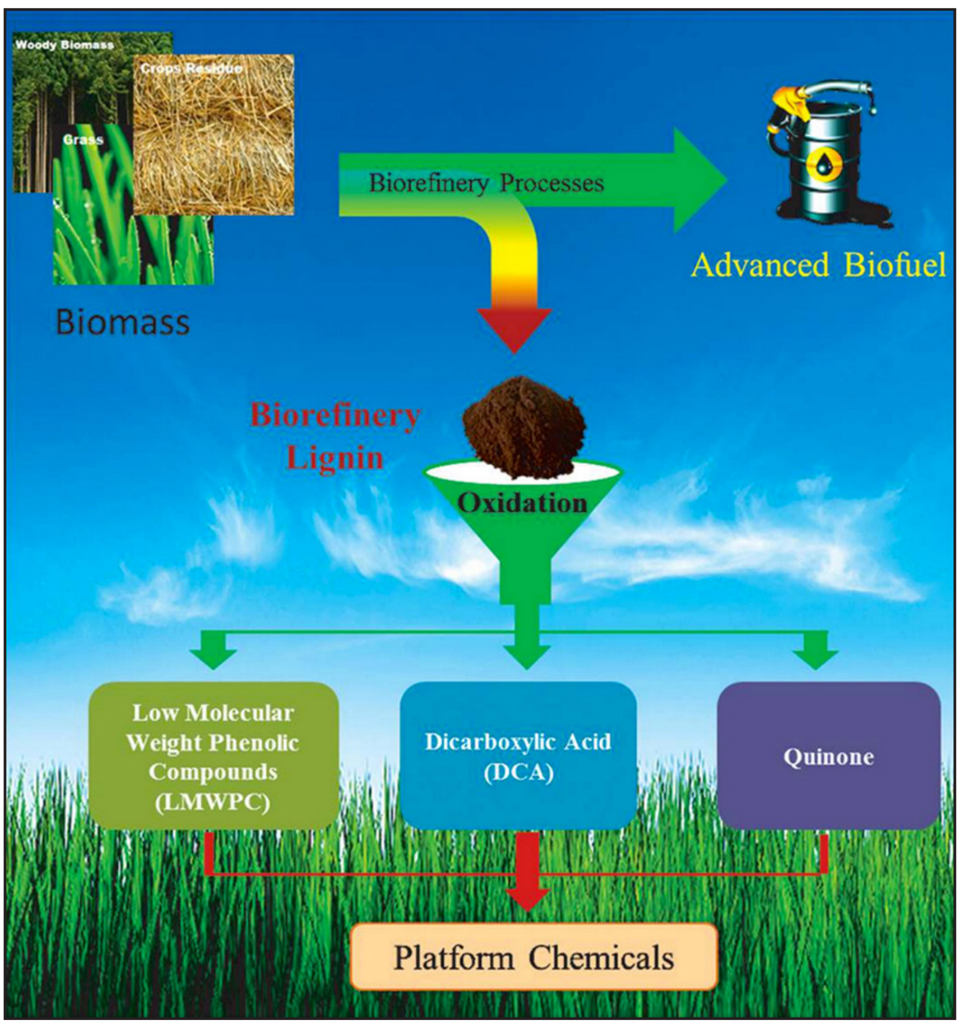
Student professional development and stakeholder benefit

The IDX students perform critical data gathering and analyses for the NARA project and for regional stakeholders. Their research results to date can be found USDA Forest Service, Forest Products Laboratory here, and all of the student research from the past four years will be incorporated into a final supply-chain analysis for the ID, WA, OR and MT region in 2016. A written report for the design analysis described in the webinar will be available soon.

Nearly 100 undergraduate and graduate students with varied majors including law, engineering, and design have participated in the IDX research for NARA. These students leave with an amazing understanding of biomass and biofuels supply chain issues and how it all works. Already, the students are getting jobs in the region as planners, architects, and engineers and becoming the bioenergy experts in their communities and in business.

The impact from these students entering the bioenergy workforce is a desired outcome of NARA's bioenergy literacy goal. An additional benefit is that data and outreach accomplished through their efforts educates Pacific Northwest stakeholders and provides a solid foundation of information for investment and planning purposes.

A review of processes used to convert biorefinery lignin into products



Cover image for Ma, R.S., Guo, M., & Zhang, X. (2014). Selective conversion of biorefinery lignin to dicarboxylic acids. ChemSusChem, 7(2), 412-415. doi: 10.1002/cssc.201300964

One of NARA's goals is to develop high value co-products made from lignin. Lignin is an abundant component in wood and is the predominant byproduct generated when bio-jet fuel is made from wood residuals. Generating high value products from this byproduct material is a key strategy for maintaining the economic sustainability of a forest residual-to-bio-jet fuel supply chain.

NARA researchers are developing high value products from the lignin-rich material generated when forest residuals are pretreated using a sulfite-based pretreatment strategy, however, there are other pretreatment strategies being developed and employed; each strategy creates a lignin byproduct that is chemically different. In addition, researchers are discovering new ways to modify lignin so that it can be used as a feedstock molecule for a wide range of products.

In light of all the exciting developments in lignin research and the importance of bringing high value products to the wood residual-to-biofuel supply chain, NARA researcher Xiao Zhang and his team have published a review article, partially funded through NARA/USDA-NIFA, that describes the lignin produced from varied commercial treatments used to produce biofuels and methods used to modify lignin to produce feedstock molecules.

Read Catalytic Oxidation of Biorefinery Lignin to Value-added Chemicals to Support Sustainable Biofuel Production here.

Lignin produced from varied pretreatments

The review provides descriptions of the varied pretreatment methods used to produce biofuels from wood material and characterizes the lignin produced from these pretreatment options which include dilute acid, pyrolysis, steam explosion, high pressure refining, ammonia-fiber-expansion (AFEX), organosolv and SPORL (sulfite pretreatment to overcome recalcitrance of lignocellulose). The lignin remaining after these treatments is either in solid form or in liquid and varies in molecular weight and hydroxyl content.

Chemistry developed by the pulp and papermaking industry

The chemical processes used by the pulp and paper industry to separate lignin from cellulose, improve the paper product, and create lignin-based chemical byproducts with commercial value are outlined. These processes include the use of reactive chemicals (oxidative reagents) like chlorine, chlorine dioxide, oxygen, hydrogen peroxide, ozone and peroxy acids that change the lignin into feedstock chemicals of commercial value. The review provides schematics for the reaction mechanisms and highlights the advantages and challenges associated with using these reactive chemicals.

Novel ways to convert lignin into chemical products using catalysts

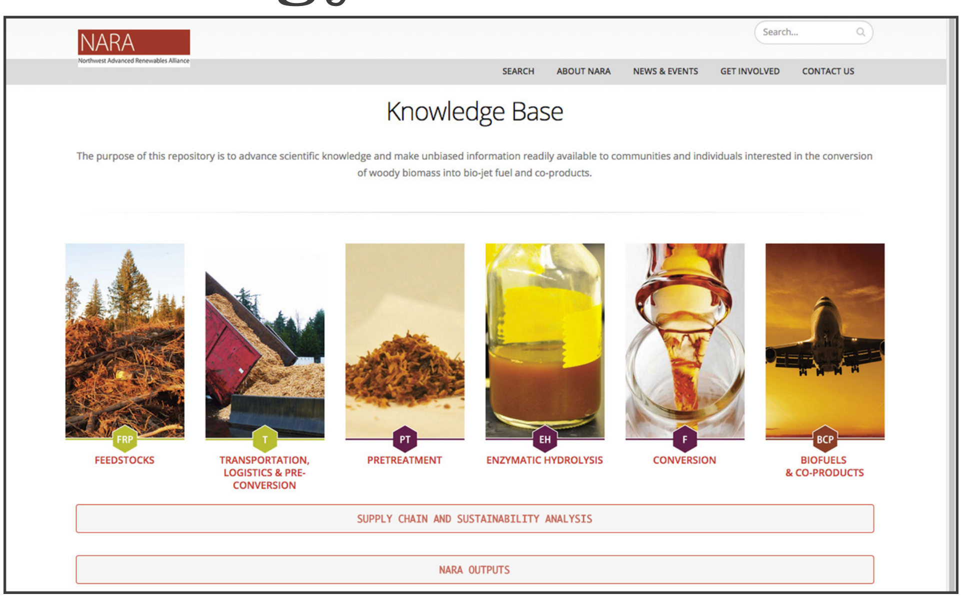
To reduce the cost of using reactive chemicals and to potentially increase product yield and specificity, novel catalysts and processes are being developed. This paper reviews a suite of catalysts that include inorganic metals, metal ions, metal oxides, composite metal oxides, polyoxometalates, organometallics, metallosalen complexes, metalloporphyrins, organorhenium oxides, vanadium complexes, metal-organic frameworks and organocatalysts. Tables and mechanism illustrations are provided that provide basic reaction conditions, substrates and the products produced from using these varied catalysts.

Promoting bioenergy literacy

This review article fits well with NARA's intent to promote bioenergy literacy. The review is structured to appeal to professionals involved with lignin research, but would also provide an interesting read for the layperson curious about how wood material can be converted into chemical products. The breath of potential products that can be made from just the lignin component is remarkable.

Dr. Xiao Zhang's team is developing novel methods to convert lignin into chemical feedstocks like dicarboxylic acids, and Dr. Zhang recently received an NSF Career Award to extended the research into utilization of dicarboxylic acids for hydrocarbon fuel and chemicals production. In the paper's summary remarks, the authors express their intent to stimulate "…new ideas and research efforts towards the development of novel catalysts, chemistries, and pathways for biorefinery lignin…". Reducing the cost and increasing the product portfolio resulting from converting biorefinery lignin into value-added commercial products will contribute significantly to the economics associated with producing fuels and co-products from forest residuals.

NARA offers searchable repository for bioenergy information



Screenshot from woodtobiofuel.org

Quality, un-biased information that addresses the use of forest residuals to produce chemical products like biofuels is abundant, the challenge is finding it. To make this information readily available to individuals and communities, NARA has produced a knowledge base repository that links to hundreds of reports, peer reviewed articles and websites.

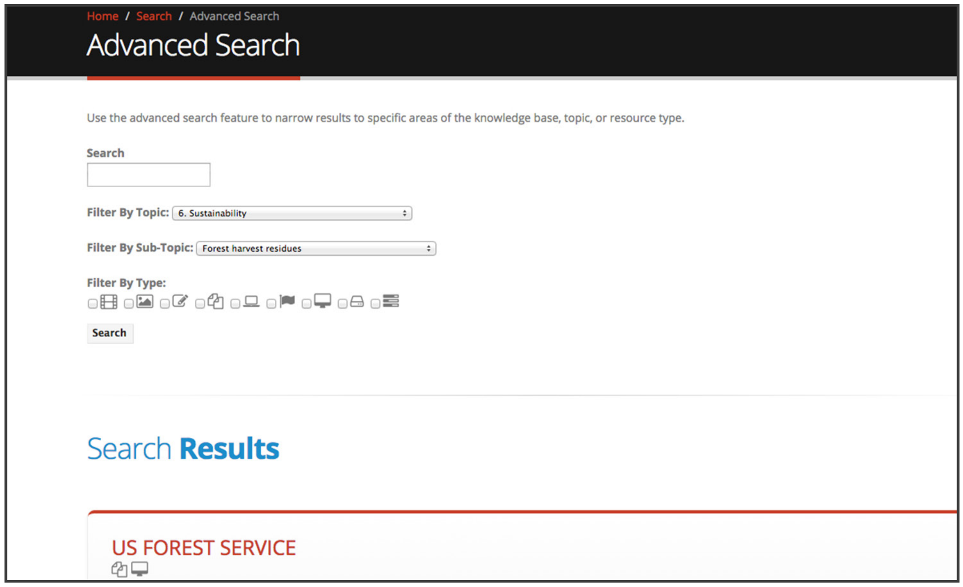
View the NARA Knowledge Base here.

One of the unique aspects to this repository is that searches can be filtered to find information for specific steps in the wood-to-biofuel conversion process. For instance, if feedstock, or pretreatment or enzymatic hydrolysis is of interest, then information specific to these areas will be highlighted.

In addition, the search function can be used to filter information regarding the environmental, social or economic sustainability associated with the use of forest residuals to make biofuels and co-products. The below image shows a search page and the type of filters used to explore the sustainability of harvesting forest residuals.

The NARA knowledgebase fits well with NARA's goal to enhance bioenergy literacy. The site offers an easy to use, non-bias portal into the primary information and research available to date on the many aspects involved with using forest residuals to produce chemical products. Over 950 users throughout the world have accessed the site since it was established in 2014.

To contribute research information to the knowledge database repository, send a pdf formatted copy or URL link to Sara Dossey at sdossey@nararenewables.org.



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