



PROMISING RESEARCH AT UW-MADISON

The Wisconsin Energy Institute (WEI) and the Great Lakes Bioenergy Research Center (GLBRC) are committed to bringing about real world, game-changing innovations that will help grow Wisconsin's economy. The WEI and GLBRC technologies listed below may offer new competitive advantages and products for a number of multi-billion dollar Wisconsin industries.

Industries: Paper, Pulping and Paperboard Manufacturing/Paper Products Manufacturing/Forestry

Zip-Lignin™ Technology

One of the key obstacles for extracting sugars from biomass is a complex polymer called lignin. Lignin, a major component of plant cell walls that gives plants their structural integrity, is the most difficult part of the plant to break down.

Professor John Ralph and his team at UW-Madison discovered that it was possible to introduce weak bonds, or "zips," into the lignin polymer, which would make it much easier and cheaper to break apart. Working with other GLBRC labs at Michigan State University and the University of British Columbia, the researchers were successful in introducing these weak links into the lignin backbone of poplar trees, resulting in biomass that is much easier to degrade.

Bottom Line: Zip-Lignin technology has the potential to reduce the costs involved in deconstructing biomass, a cost-reduction with wide ranging effects on both the paper industries and the future of cellulosic biofuel and bioproducts production in Wisconsin.

GVL

Extracting sugars cost-effectively from biomass is a key barrier to producing fuels and chemicals from plants. Traditional methods of extracting the sugars involve the use of expensive chemicals such as concentrated acids and enzymes.

UW-Madison Professor James Dumesic and his team have discovered that by using gamma valerolactone (or GVL), a chemical that can be produced from plants, they can deconstruct biomass and produce sugars that can be chemically or biologically upgraded into biofuels or chemicals. Since GVL is created from plant material, it's both renewable and more affordable than conversion methods requiring expensive chemicals or enzymes.

Bottom Line: GVL has the potential to create cost-disruptive biorenewable fuels and chemicals for a wide range of Wisconsin industries. This one-step process is much cleaner and more affordable than conversion methods requiring expensive chemicals or enzymes, and could thus "green" a number of industries – biofuels and paper and pulp once again chief among them.

Engineered Softwood

Hardwoods and softwoods are both utilized in the pulp, paper, and biofuels industries. Softwoods, such as conifers, have long fibers well suited for use in making strong paper products such as shipping containers and grocery bags. But softwoods are also more difficult to deconstruct than hardwoods. In addition, the sugar found within softwoods converts more easily and in higher volume to ethanol, making softwoods a potentially superior feedstock for biofuels.

Like most plants, hardwoods and softwoods contain lignin, the notoriously hard-to-process "glue" that lends plant tissues their structure and sturdiness. The lignin in hardwoods, however, is easier to degrade. UW-Madison professor John Ralph has demonstrated the potential for softwoods to process more easily if engineered to incorporate key features of hardwoods' lignin.

Bottom Line: By pairing the most economically desirable traits of each wood type, it's possible to decrease the intensity of processing techniques and increase yields across a variety of industries. Not only could this have a significant economic impact on Wisconsin's multi-billion dollar paper and pulp mill industry, it could also have the tangible environmental benefits of reducing the energy required for processing and the amount of waste produced.

Industries: Paper, Pulping and Paperboard Manufacturing/Paper Products Manufacturing/Plastic Products Manufacturing/Agriculture/Forestry

Biomass-Derived Aromatics

Lignin, the natural “glue” that gives plants their structural integrity, comprises about 30 percent of most biomass. In most paper and pulping mills, lignin is a near waste product burned for process heat.

UW-Madison professor Shannon Stahl, however, has developed a novel way to convert lignin into high-value chemicals. Stahl and his team discovered an efficient, cost-effective method for breaking down lignin's six-carbon rings – the “aromatics” – into individual components. Traditionally sourced from petroleum, aromatics are used in a wide variety of products, including plastic soda bottles, Kevlar, pesticides, pharmaceuticals, and are essential components of jet fuel.

Bottom Line: Converting what has been a large volume waste product into a new source of renewable aromatics could transform the economics of industries that process wood and other biomass into paper and paper products. Stahl's method also helps open the door to a more economical way forward in replacing petroleum-based fuels and chemicals with biorenewable materials. This can provide new markets for agriculture and forestry sectors and new supply chains for Wisconsin's plastics products manufacturing industry.

Industries: Agriculture

Smartscape

UW-Madison professor Claudio Gratton is developing a user-friendly planning software that allows farmers, conservation agencies, and state, federal, and county land managers such as DNR to model and map changes in specific parts of the landscape, piece-by-piece. After selecting a potential change – say from a row crop such as corn and soy on highly erodible land to a perennial grass bioenergy crop – users can measure the potential differences in the output of ecosystem services. These services, such as pollinator habitat, soil runoff protections, and carbon sequestration, can be compared to changes in net income.

Bottom Line: This software will allow users at multiple levels of social, political, and economic capacity to make informed decisions about the benefits of different outcomes of private and public land use in Wisconsin, and has already been showcased in stakeholder meetings as a way to demonstrate the value of changes in land use over time.

Bioenergy Crops on Marginal Lands Improve Ecosystem Services

Corn may out compete switchgrass and prairie when farmer income is the only concern, but data compiled by Doug Landis at MSU and a team of collaborators at GLBRC demonstrate that perennial grasses support greater biodiversity and higher rates of a variety of services such as pest suppression and pollination that increase ecosystem health and sustainability. Planting perennial energy crops on marginal lands could maintain or enhance these functions, complementing and even feeding back to benefit commodity production on prime agricultural land, providing a means to support bioenergy goals, broaden the portfolio of services supported by agricultural landscapes, and support their long-term functioning.

Bottom Line: Moving toward a second generation of biofuel production that includes some perennial crops can allow farmers to maintain the health of their soil while increasing biodiversity and reducing use of pesticides that harm populations of beneficial bugs that act as natural predators to corn and soybeans.

Fungicide Discovery by WEI/GLBRC Researchers Being Scaled for Use In Agriculture

A chemical compound called poacic acid could eventually be used as a fungicide in both sustainable and conventional farming.

Poacic acid may have the potential to replace copper sulfate, which is used as a fungicide in organic agriculture but accumulates to toxic levels in soil, according to Jeff Piotrowski, WEI/GLBRC scientist. In addition, it could also be used in combination with synthetic fungicides, to lower dosage or reduce the chances of developing resistance.

Bottom Line: Poacic acid may ultimately provide a natural fungicide option in a time when such options are not abundant, fungicide resistance is on the rise, and warming temperatures are increasingly causing fungal pathogens to spread northward.

Industry: Electrical Equipment Manufacturing

Supercritical CO2 Gas Turbines

Capital costs and power generation efficiency are two major hurdles in reducing the cost of generating electricity. Traditional power plants generate electricity by combusting fuel to heat water into steam, which in turn drives a steam turbine to generate electricity. However, the extraordinary properties of supercritical carbon dioxide – a fluid with qualities of both a liquid and a gas – make it an exciting prospect as a replacement for steam turbines as a way to generate electricity.

Mark Anderson, an engineering physics research professor at UW–Madison, is doing research that will aid in developing large-scale supercritical CO2 advanced power systems. Anderson is currently working with industry in Wisconsin to start production of key components for the supercritical CO2 closed-cycle gas turbine.

Bottom Line: Replacing a steam turbine system with a closed-cycle gas turbine using supercritical carbon dioxide could increase power generation efficiency by 50 percent or more, resulting in a significant reduction in the cost of electricity. This technology could have significant impact on every power generation technology, including nuclear, natural gas, wind, and solar. Wisconsin industries have already begun collaborating to develop parts for the supercritical CO2 turbine supply chain.

Microgrids

Microgrids are small, self-contained electric-power grids with the capability to connect and disconnect seamlessly from the traditional grid. Natural disasters such as Hurricane Sandy, which left many without power for weeks, have substantially increased interest in the Northeast and elsewhere in using microgrids to ensure resilience in electricity supply. U.S. military installations, forward operating bases, and naval ships are also deploying microgrids to save money and secure their energy supply.

University of Wisconsin-Madison researchers have been at the forefront of developing a microgrid architecture that provides rapid and stable adaptation to new system dynamics, integrates distributed power sources into the electrical grid, and enables greater efficiency by moving power generation closer to the consumer, creating opportunities to utilize waste heat.

Bottom Line: Power outages and grid failures are estimated to cost American businesses more and \$100 billion annually. Microgrids can enhance system reliability, stability, and resilience for their users. UW–Madison's expertise in microgrid research helps keep Wisconsin at the forefront of this expanding market and may provide new products and supply chains for Wisconsin's electrical equipment manufacturers.

See more of our technologies on the Wisconsin Alumni Research Foundation website: <http://goo.gl/oAjis5>