Science and Engineering for a Biobased Industry and Economy

Petroleum and other nonrenewable fossil fuels are commonly used for fuels, energy, plastics, industrial chemicals, pharmaceuticals, cosmetics, and other materials we use on a daily basis. But many of these products can be made using plant compounds, oils, and fiber. Dedicated feedstock crops are an important source of biomass and bioproducts. They can also be derived from food and agricultural wastes like corn stalks, wood chips, and nut and soybean hulls. Recycling agricultural wastes into bioproducts reduces the need for incineration, landfills, and other disposal methods that contribute to global warming and harm human health and the environment. Creating bioproducts from agricultural wastes also conserves land for food production and other needs and provides farmers additional revenue streams.

Biofuels and other bioproducts offer a way to improve energy security, food security, and national security while also cutting back on fossil fuel-related pollution and climate change. Biobased industries can also generate new jobs and economic activity nationwide.

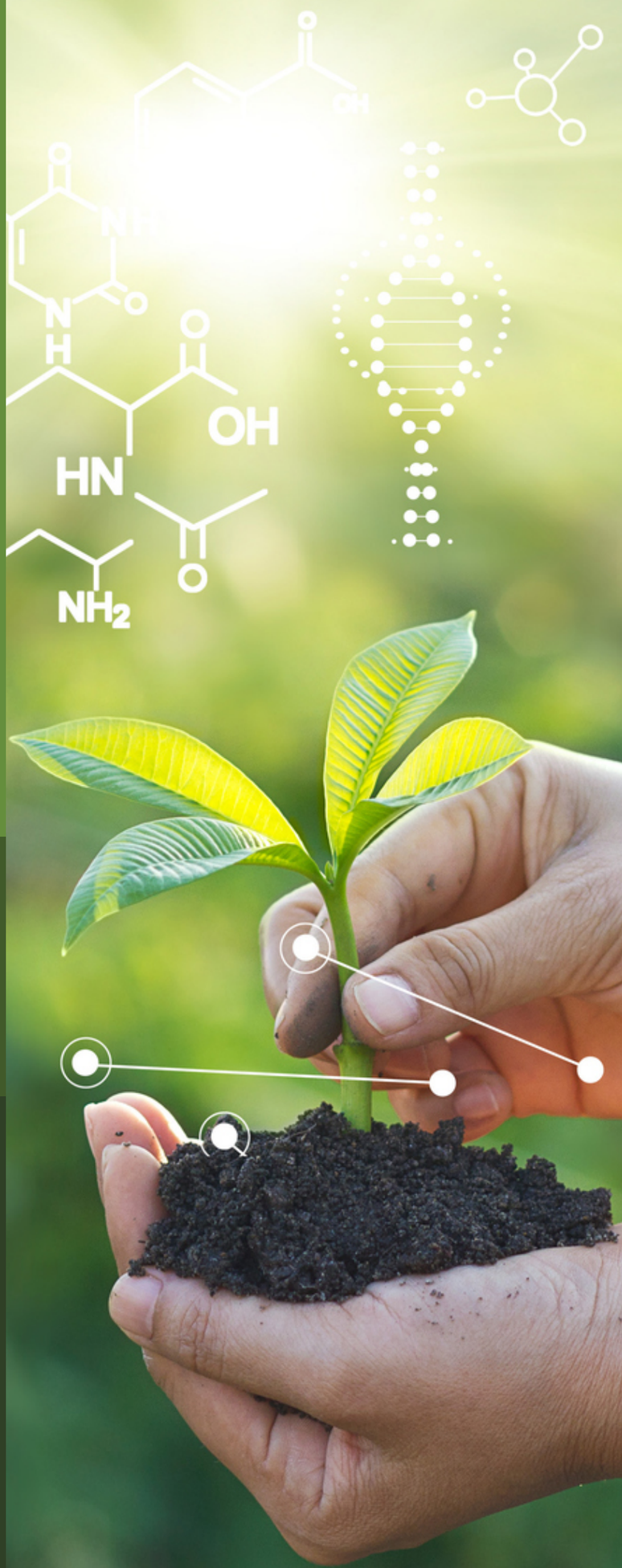
At land-grant universities across America, scientists, engineers, and educators are working together to develop and provide the information, tools, technology, and skills needed to successfully deploy sustainable biobased systems.

The multistate structure provides numerous benefits.

Collaboration allows scientists with diverse expertise and skills to share knowledge and resources. Coordination reduces unnecessary duplication of efforts, and regular meetings help scientists stay on top of innovations and emerging issues. Connection and support also keep project members engaged, facilitating long-term research and development.

The Land-grant University System has unique assets that boost this project's capacity for impact.

Land-grant universities have state-of-the-art labs; experimental fields in various environments; a widespread network of Extension educators and communicators to share findings, technology, and practices; and strong relationships with government agencies, non-profits, farm and commodity groups, and the private sector. Through university teaching positions, project members are able to develop future scientists, engineers, farmers, and bioindustry professionals.



Multistate Research Fund
IMPACTS

Research Highlights

Researchers enhanced existing biomass feedstock, identified new biomass sources, and developed new bioproducts. For example:

- Low value lactose from large dairy manufacturing sites can be used to affordably produce PHA (a biodegradable biobased plastic with a wide range of applications including packaging films and containers) at commercial scales. *California*
- Pigments extracted from corn can be used as natural food dye that is safer than the commonly used petroleum-based Red 40 dye. *Illinois*
- Researchers extracted and patented antimicrobial compounds from lignin bio-oil. *Kentucky*
- Experiments could result in biobased nanocellulose that can be used to heal wounds. *Virginia*
- Forest residues could be used to create aerogel biosorbents that remove toxic heavy metals from water bodies. *Wisconsin*
- Genetically modified camelina uses nitrogen more efficiently and is more suitable for biofuel production. *Montana*
- Switchgrass and miscanthus can produce high biomass yields on low quality soils. *New York*
- Industrial hemp can be used in numerous bioproducts and has potential to be a major commodity crop in the southern U.S. *Kentucky*
- Duckweed is economically viable for New Jersey farmers. *New Jersey*

Researchers developed technically feasible, cost-effective, sustainable technologies for converting biomass into useful materials and identified reliable, economical systems for producing, storing, and transporting biomass. Specifically, researchers:

- Patented a way to create syngas from municipal solid wastes and switchgrass produces more gallons per year than traditional technologies and would result in an estimated $33 million increase in a biorefinery's annual net revenue. *Oklahoma*
- Developed no-till production systems for sugar beets (commonly used for ethanol) that improve soil health and save farmers about $110 per acre in fuel, machinery, and labor costs. *Montana*
- Identified a new co-fermentation strategy that drastically improves ethanol yield from cellobionate and glycerol. *California*
- Developed a microwave-assisted process that improves the yield and quality of bio-oil and syngas made from biomass and plastic wastes. *Minnesota*
- Identified gentler pretreatments that cost-effectively convert biomass into biofuels with fewer environmental impacts. *Illinois*
- Developed a biomass pretreatment that reduces water, energy, and chemical consumption. *Kansas*
- Pioneered new pretreatment and manufacturing technologies to process biomass into jet fuel, bioplastics, and carbon fiber. *Washington*
- Designed a new horizontal reactor that minimizes the energy needed to mix biomass with the enzymes used to break it down for ethanol production. *Oregon*
- Found a way to produce graphene from agricultural and biochar wastes that can be used to manufacture bio-based capacitors, semi-conductors, ink for 3D printers, and more. *Texas*
- Designed a mobile biorefinery system to convert waste flare off gas from coal power plant into liquid biofuel. *Mississippi, Choctaw Coal Energy*
- Optimized processes and technologies for producing biosurfactants, which can be used as cleaning products, preservatives, and more. *Iowa*
- Developed novel methods to rapidly separate lignin from lignocellulosic biomass for production of aromatic chemicals. *Louisiana*
- Developed techniques to modify lignin so it can replace petroleum in phenols and acrylates, which are used in antiseptics, resins, and more. *Tennessee*
- Identified a process for using plant oil extraction byproducts to create affordable, durable, biodegradable fast food packaging. *Kansas*
- Developed an algal-bacterial process to treat poultry processing wastewater so it is safe to use in hydroponic irrigation. *Alabama*
- Discovered a process that efficiently isolates cellulose nanocrystal and nanofiber from sawdust, prairie cordgrass, and corn stover so it can be used in biopolymers and "smart" fertilizer. *South Dakota*
- Developed new bioprocesses for producing high-value bioproducts from lipid feedstocks, organic wastes, and microalgae. *Hawaii*
- Outlined parameters for successful systems in which brine shrimp convert algae into higher value biomass for bioenergy production. *Missouri*
- Pioneered research on the way brown rot fungi breaks down cellulose, which has been advanced and patented by other researchers at national institutes and labs. *Massachusetts*
- Showed that biochar—the carbon and ash byproduct of heating biomass in the absence of oxygen—can be applied to land to improve soil health and sequester carbon in soil instead of releasing it as a greenhouse gas. *Michigan*
- Showed ethanol biorefineries how to improve long-term profitability by creating allulose (which is used as a low-calorie sweetener) in addition to ethanol during fermentation. *Illinois*
- Calculated that biogas made from anaerobic digestion of animal manure can be competitive with natural gas prices. *Iowa*
- Demonstrated the potential for carbon-negative bioprocessing. *North Carolina*

Models, pilot tests, technical reviews, and other efforts are facilitating the adoption of biobased systems. For example:

- Calculated the life cycle sustainability and costs of new biobased products and processes, which helps policymakers, farmers, and processing companies make decisions. *Michigan, Ohio*
- Helped establish startup companies to commercialize technologies that use agricultural and forestry wastes for bioproducts. *South Dakota*
- Developed commercial-scale systems to help with adoption of gasification technology. *Texas*
- Designed and modeled an algal pond system and a freshwater shellfish pond system that can sustainably produce biomass and biofuels while also capturing carbon; worked with Clemson University facility services to adopt the systems and reduce the campus carbon footprint. *South Carolina*

Workshops, simulations, publications, field days, and other materials informed farmers, industry professionals, and the public about biobased systems. Project members also provided education, mentorship, research experience, and networking opportunities for diverse students, helping them secure jobs.

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Learn more: *https://bit.ly/MRF-S1075*

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