100 Years of Service

Forest Products Laboratory

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Facility Construction Proposal Overview for the FPL Bioenergy Pilot Plant

As a Nation, we need to reduce carbon emissions believed to cause climate change and reduce U.S. dependence on foreign oil. Use of renewable and alternative fuels can substantially mitigate these problems. The President's New Energy for America plan sets a goal of at least 60 billion gallons of advanced biofuels by 2030. According to the Department of Energy (DOE), meeting these goals requires that a significant portion of the fuels be cellulosic-based ethanol and that technology be significantly improved.

Currently, large areas of U.S. forestlands contain unnaturally high accumulations of forest biomass. Fires on these overstocked forests have proven to be more intense and harder to control. An estimated 8.4 billion dry tons of material should be removed from our Nation's forests, and a significant portion of this could be available for production of wood products, chemicals, and energy. We must find profitable uses for the removed forest biomass to reduce the cost of forest management.

In addition, increasing global energy demand is putting greater pressure on easily extractable fossil fuel reserves. As fossil fuel usage increases, liquid fuels and chemical feedstock produced from renewable and sustainably grown woody forest biomass are becoming more desirable. Trees are one of the best sources of biological fuel and chemicals—they grow in soils that may not be suitable for other plants; use less fertilizer, herbicides, and pesticides than do agricultural materials; and can accumulate biomass for several years before being harvested.

Combustion of fossil energy resources is increasing the atmospheric concentration of carbon dioxide and other greenhouse gases, which in turn can contribute to climate change. Fuels derived from biomass are generally regarded as greenhouse gas neutral. As international concerns over global change and greenhouse gas generation rise, support for biological fuels will likely increase and reduce investment risks.

Cost-effective conversion of lignocellulose into fuel and chemicals requires innovative breakthrough research in several areas:

- Improved methods that reduce collection and transportation costs
- Pretreatments that make more cellulose available for enzymatic saccharification or derive value from lignin
- Efficient ways to use the five-carbon sugars in hardwoods
- Value from resistant cellulose
- Co-production of specialty chemicals with greater value than ethanol and paper pulp
- Improved gasification with less char and higher energy yield
- Transportation fuels and higher value chemicals from product gas

The Forest Products Laboratory (FPL) is well suited for research to improve the economics of producing fuel and chemicals from biomass. Development of economically viable biorefineries will help reduce the cost of forest management, dependence on fossil fuels, and production of greenhouse gases. Building on a long history of wood science, handling and treating wood, and our ability to develop strong multidisciplinary teams, FPL experts in cellulose chemistry, microbial fermentation, biochemistry, and engineering will work together with Federal university and industry partners to develop and scale-up economical bioconversion and thermo-conversion technologies for woody biomass into biofuels.

Proposed Facility

The proposed Bioenergy Pilot Plant will provide a research facility and pilot plant for development, scale-up, and evaluation of technologies for commercially viable conversion of biomass to fuels, alternative energy sources, and related chemicals and products. The envisioned 50,000-square-foot facility will provide research and analytical laboratories, computer laboratories, high-bay pilot plant space, and facility and occupant support spaces. The proposed location is on the north end of the main Forest Products Laboratory campus in Madison, Wisconsin.

The cost of the proposed project is $72.4 million ($5.1 million design/engineering, $34 million facility construction, $23.9 million plant equipment, and $9.4 million furnishings and benchtop equipment). These cost estimates have recently increased to include additional research capacity for all three major pathways for producing fuels and chemicals from biomass, and for an expanded partnership with the Agricultural Research Service (ARS).

Microbial and Biochemical Technology

Recent technological and economic developments have greatly advanced biorefining as a viable approach for agricultural and herbaceous lignocellulosic residues. Biorefining of woody biomass, however, remains a significant challenge. Biorefining requires an effective pretreatment, efficient enzymatic hydrolysis. and high-yield fermentation of the resulting sugars. Although several technological approaches are available at the laboratory scale, they have not yet been proven at the pilot scale. Moreover, commercial implementation will require evaluation of many wood species, residue types, age distributions, regional variants, and harvest cycles. In addition, biorefining has the potential to make high-quality fibers and polymeric lignin byproducts that will need to be tested at a relatively large scale. Molecular biology research will be conducted to cost-effectively ferment sugars derived from woody biomass. At pilot scale, typical activities include fermentation to evaluate strain stability and performance at 1/100 to 1/10 of commercial scale.

Thermochemical-Conversion Sciences

Thermo-conversion of woody biomass to fuel involves using a gasifier to recover combustion gases in an ultra-efficient manner to produce energy. Depending on temperature and other conditions, the process yields syngas or syngas/pyrolysis oil which can both be converted into liquid transportation fuels. Thermo-conversion to syngas with hydrogen enrichment is quite flexible, tolerating a broad range of biomass resources (e.g., corn stover, municipal yard wastes, and forest vegetation treatment residuals, including tree limbs, tops, needles, leaves, and other woody parts). Thermo-conversion research objectives include scale-up of an innovative bench-top gasifier to pilot-scale gasifier, with the ultimate goal of developing a scalable distribution gasification unit that may be operated efficiently at a 1- to 10-megawatt scale in remote areas. Commercial utility providers could scale up a successfully demonstrated mobile gasification unit to provide input fuel for a power plant of up to 300-megawatt capacity at a centralized location.

Biochemical Conversion Sciences

The FPL and the ARS (Office of Technology Transfer; Natural Resources and Sustainable Agricultural Systems; Midwest Area Office) have recently discussed a collaborative biofuels research and development program that could leverage current resources both agencies have in Madison, including the former and currently vacant ARS Cereal Crops Building. This proposed expanded program, with the addition of substantial new resources, would allow USDA to increase its role in the biofuels development arena and create a mechanism to partner with the DOE-funded Great Lakes Bioenergy Research Center at the University of Wisconsin–Madison.

ARS welcomes collaborative and synergistic research with FPL for the biorefining of lignocellulosic biomass into fuels and value-added co-products. The relative amounts of lignin, hemicellulose, and cellulose differ, but the basic lignocellulosic building blocks of plant cell walls are quite similar irrespective of the source (woody or herbaceous).

The ARS has in Madison, Wisconsin, a longstanding national center for research on the original cellulosic biorefinery process—ruminant digestion, a process that is very similar to what would happen in an enzymatic biorefinery for cellulosic–lignocellulosic ethanol. In fact, the ARS National Dairy Forage Research Center on the University of Wisconsin–Madison campus has an active research project on microbial conversion of cellulosic feedstocks into ethanol and value-added co-products. This ARS laboratory also collaborates closely with ARS researchers at several other locations.

Project Summary

The aggressive goals of the President's Advanced Energy Initiative for renewable and alternative fuels production cannot likely be met without commercial production from woody (lignocellulosic) biomass. FPL scientists, in collaboration with ARS, university, and industry partners, are poised to initiate development and scale-up of conversion technologies for biomass into liquid fuels but lack the facilities to prove such technology to industry partners. The proposed pilot plant would facilitate improved efficiency of innovative technologies and expedite scale-up and commercialization of existing bench-scale processes for conversion of cellulosic materials to fuel. Because the facility's primary focus will be on conversion of wood to fuel, along with fiber and polymer byproducts, it will not duplicate pilot facilities in other laboratories.

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