

## Economy Through Product Diversity: **INTEGRATED BIOREFINERIES**

Achieving national energy and climate goals will require an economically viable and environmentally sustainable U.S. bioindustry. A crucial step in developing this industry is to establish integrated biorefineries capable of efficiently converting a broad range of biomass feedstocks into affordable biofuels, biopower, and other products.

Integrated biorefineries are similar to conventional refineries in that they produce a range of products to optimize use of the feedstock and improve process economics. Integrated biorefineries, however, must employ new technologies and feedstocks—requiring significant technology development, integration, and financial risk.

The U.S. Congress has set an ambitious goal for the nation to produce 21 billion gallons of advanced biofuels in 2022. This target creates an urgent need to bridge the gap between promising research and commercial, large-scale production of advanced biofuels.

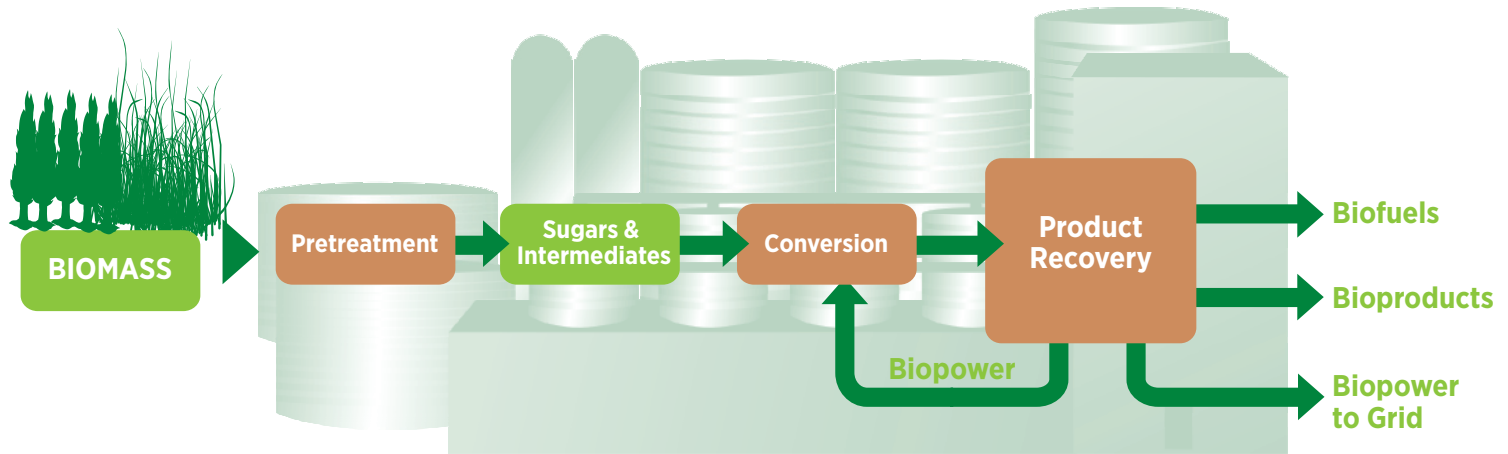
To help develop, integrate, and validate novel technologies for commercial use, the U.S. Department of Energy's Biomass Program works in partnership with industry to help launch biorefineries at various scales. These biorefinery projects are located around the country and use a range of feedstocks to produce diverse fuels and products. Federal support for large-scale, first-of-a-kind integrated biorefineries can significantly reduce the financial risk for these projects and thus speed the growth of the biomass industry.



Developing the next generation of biofuels is key to our effort to end our dependence on foreign oil and address the climate crisis—while creating millions of new jobs that can't be outsourced.

— Energy Secretary Steven Chu

## Sample Integrated Biorefinery: Biochemical Conversion (one of many options)



## What Is an Integrated Biorefinery?

Integrated biorefineries convert biomass into liquid transportation fuels, high-value chemicals, and other biobased products, as well as heat and power. As in an oil refinery, feedstocks are converted into a slate of products through multiple technology routes. Fuel production provides a large-volume product to achieve economies of scale, while lower-volume, biobased co-products and power production can improve the economics of the facility. Integrated biorefinery systems are being evaluated for their feasibility to produce fuels and products for potentially large commercial markets. A major challenge is to develop the ability to convert diverse biomass components into value-added products as efficiently as the current petrochemical industry.

### *Key Challenges:*

- **Deployment and financing of new technologies:** Integrated biorefineries require the deployment and validation of new technologies and processes, which entail significant financial and technical risks. Attracting financing for large industrial projects that rely on new technologies is always challenging—but particularly in current markets and time of tight credit.
- **Expanding markets for products:** Beyond the technical solutions, integrated biorefineries must establish adequate market demand for their products—if they are to become economically viable.

- **Economic viability:** Products from integrated biorefineries must be competitive in the marketplace.
- **Diverse feedstocks:** Biorefineries will use different biomass feedstocks across the nation, posing a challenge to development of replicable feedstock supply systems and conversion technologies.
- **Permitting:** Obtaining proper permits can be complicated. Each integrated biorefinery is unique and usually does not conform to an existing industrial footprint.
- **Sustainability:** As technologies for feedstock production and conversion are developed and scaled up to meet national biofuel targets, the economic, environmental, and social impacts must be carefully modeled and monitored on a life-cycle basis.



Photo courtesy of DOE/NREL

## Sample Program Activities:

The Biomass Program works with the National Laboratories and industry partners to address critical challenges in the establishment of integrated biorefineries. Biorefinery projects help prove the viability of various conversion pathways using diverse feedstocks to produce a range of biofuels and bioproducts as well as heat and power.



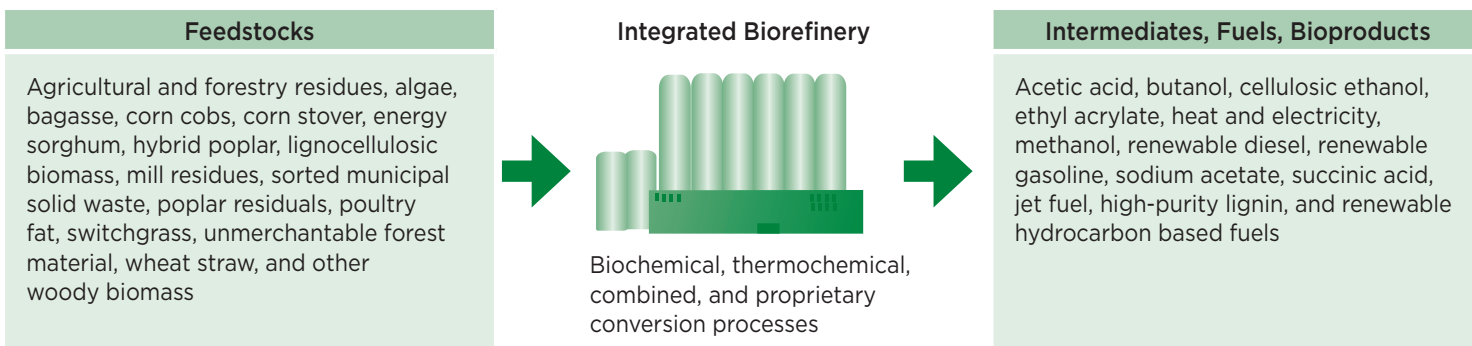
- **Pilot-scale projects:** Prior to investing in large-scale demonstrations, the Department of Energy (DOE) validates key technologies through pilot-scale demonstration projects, which typically process about one ton of feedstock per day. In 2009, DOE announced that it will invest funds from the American Recovery and Reinvestment Act (ARRA) in 12 pilot-scale biorefinery projects.
- **Demonstration-scale projects:** Once a technology has been validated in a laboratory or at the pilot scale, a demonstration at 10% of commercial scale may be desirable to further reduce technical and financial risks and prove readiness for a commercial-scale project. In fiscal year 2008, DOE initiated several demonstration-scale projects to be funded through regular appropriations. In 2009, DOE announced that ARRA funding will be used to support additional demonstration-scale biorefinery projects (at a minimum of 50 tons of biomass per day), bringing to 10 the number of DOE demonstration-scale projects.
- **Commercial-scale integrated biorefineries:** These projects are designed to demonstrate the cost-effective and replicable production of cellulosic biofuels and other products at a commercial scale. DOE is currently cost-sharing development of five commercial-scale integrated biorefineries, which will have production capacity of up to 80 million gallons of cellulosic biofuel annually by 2014. Progress will depend on obtaining the additional funding needed to complete these public-private projects.



Photos courtesy of DOE/NREL

All of our biorefinery projects beyond the laboratory scale are carried out by private industry with financial and other assistance from DOE and other government agencies. Collectively, these projects are exploring a range of feedstocks and conversion pathways to produce biofuels, biopower, and other products.

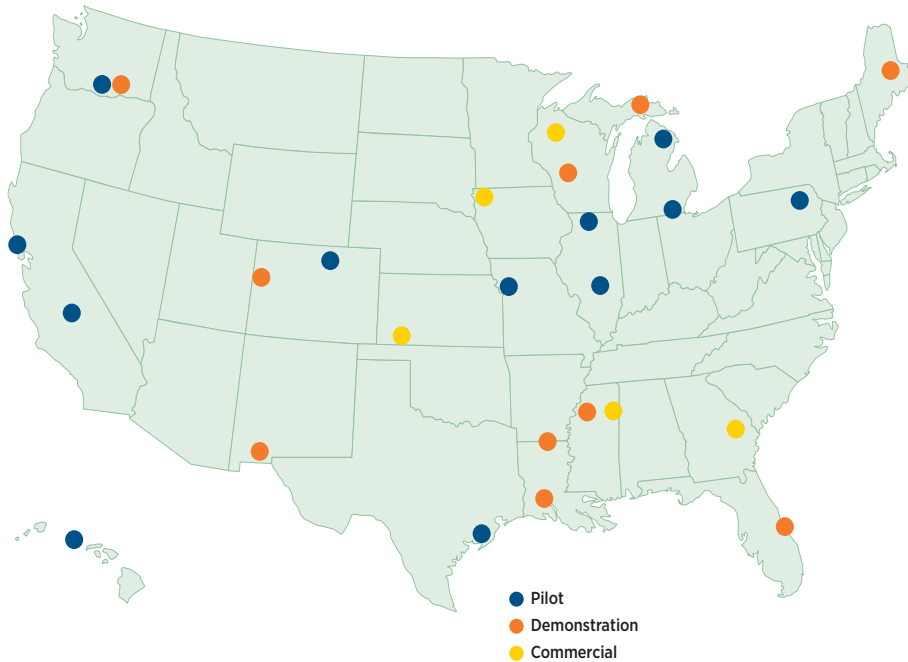
## Diverse Feedstocks and Products



## Pilot, Demonstration, and Commercial-scale Projects

Strategically locating our biorefinery projects in different geographical areas of the country promotes local and regional economic development, national energy resilience, and conversion technologies optimized for the biomass feedstocks in each region.

### Integrated Biorefinery Project Locations



For the latest project information and details, please visit our website:  
[www.eere.energy.gov/biomass/integrated\\_biorefineries.html](http://www.eere.energy.gov/biomass/integrated_biorefineries.html)

For additional information visit: [www.biomass.energy.gov](http://www.biomass.energy.gov)

March 2010

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy

For more information contact  
EERE Information Center  
1-877-EERE-INF (1-877-337-3463)  
[www.eere.energy.gov/informationcenter](http://www.eere.energy.gov/informationcenter)