Biofuels, Biopower, and Bioproducts: INTEGRATED BIOREFINERIES

Photos courtesy of iStockphoto and National Renewable Energy Laboratory

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.

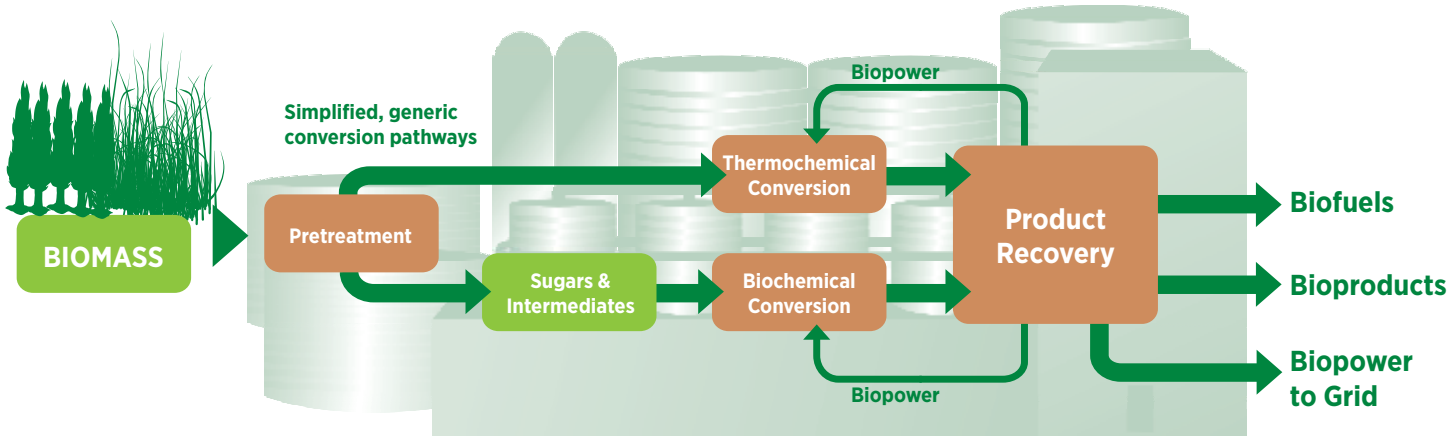
— Energy Secretary Steven Chu

The United States has set a goal to produce 21 billion gallons of advanced biofuels by 2022. This target creates an urgent need to bridge the gap between promising research and commercial, large-scale production of advanced biofuels. Achieving national energy and climate goals will require a large, 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 bioproducts. Integrated biorefineries are similar to conventional refineries in that they produce a range of products to optimize both the use of the feedstock and production economics. Integrated biorefineries employ novel technologies and diverse biomass feedstocks—requiring significant investments in research, development, and deployment projects to reduce costs and otherwise improve competitiveness with fossil fuels.

The U.S. Department of Energy's (DOE's) Biomass Program works in partnership with industry to develop, build, operate, and validate integrated biorefineries at various scales (pilot, demonstration, and commercial). These projects are located around the country and use a range of feedstocks and conversion technologies. Federal support for first-of-a-kind integrated biorefineries can validate the costs and significantly reduce the technical and financial risks associated with new technology deployment, thus accelerating growth in the U.S. bioindustry.

Integrated biorefineries use various conversion pathways.

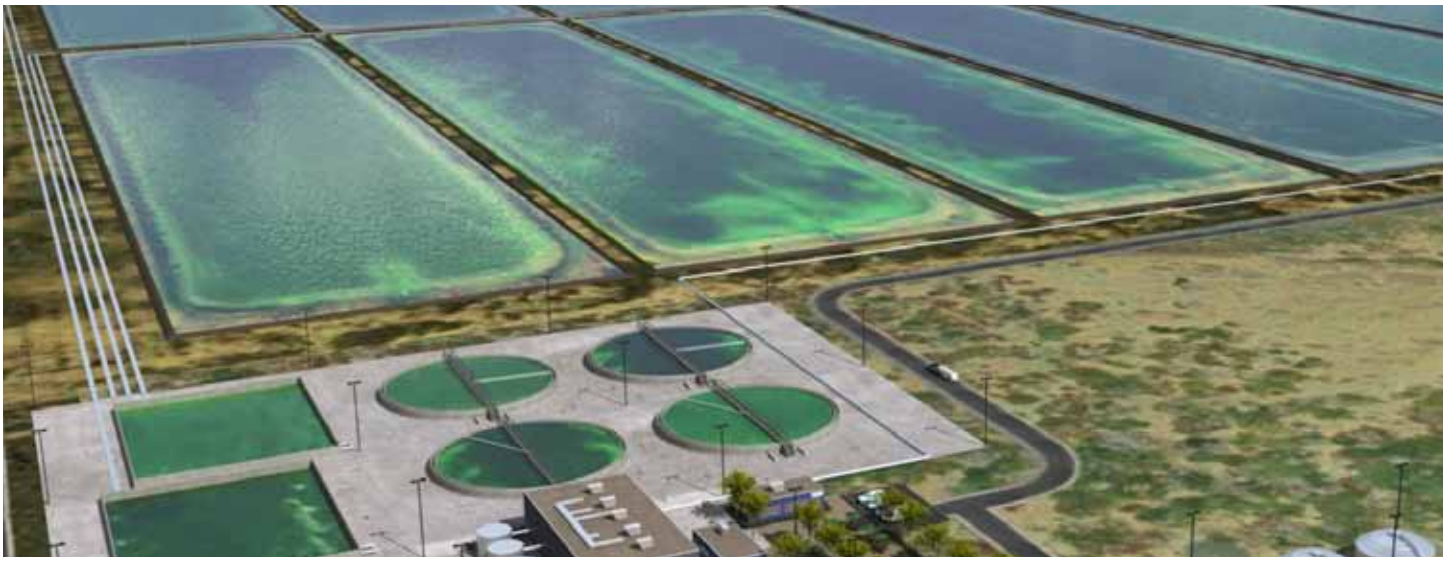


Key Challenges:

Diverse challenges hinder rapid growth in the U.S. bioindustry.

- **Financing New Technologies:** Deployment and validation of new technologies and processes entail significant financial investment and technical risk. Financing of pilot, demonstration, and commercial-scale projects that use innovative technologies and diverse feedstocks is always challenging—but particularly in times of tight credit, as in the current market.
- **Market and Economic Viability:** Integrated biorefineries must optimize the use of biomass to create a product mix that is matched to market demand and can compete with fossil fuels.
- **Feedstock Diversity:** Biorefineries can use a variety of biomass feedstocks across the nation, capitalizing on each region's geography and climate. This diversity creates a challenge to developing replicable feedstock supply systems and specialized conversion technologies.
- **Permitting:** To obtain proper permits, each biorefinery must establish community support and evaluate its potential environmental impacts. This process can be complicated as the specific conversion process and feedstocks used in each biorefinery affect the facility's environmental footprint and impacts on the community.
- **Sustainability:** Economic, environmental, and social impacts must be carefully modeled and monitored on a life-cycle basis.
- **Consistent RD&D Investments:** Government, academia, and industry have made significant investments in the development of feedstock and biorefinery technologies to foster growth in the nascent bioindustry. Many of these technologies remain in the early stages of development and will need ongoing, consistent support if the nation is to meet legislated production goals for advanced biofuels.

DOE provides cost sharing for biorefinery projects to validate novel conversion processes and reduce the technical and financial risks to future investors. (Photo courtesy of DOE/NREL)



Sapphire Energy, one of nine companies selected by DOE for a demonstration-scale biorefinery project, is building an integrated algae-to-energy farm in Columbus, New Mexico. (Artist's rendering courtesy of Sapphire Energy)

Integrated Biorefinery Deployment Activities:

The Biomass Program works through public-private, cost-sharing partnerships to address critical challenges in the deployment of technologies for integrated biorefineries. These biorefinery projects prove the viability of various feedstock and conversion pathways and reduce technical and financial risks by following a progression from pilot to demonstration scale and from demonstration to commercial scale. Each step in this progression enables validation of production performance at scale, paving the way for commercial readiness.

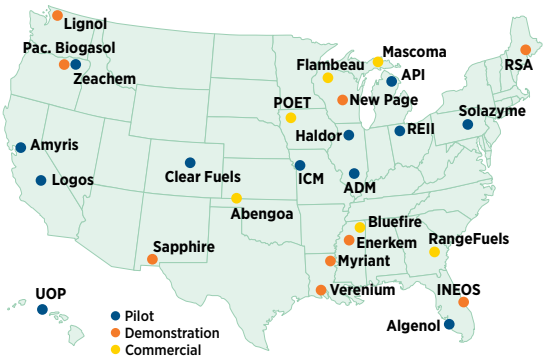
- **Pilot-scale Projects:** Promising technologies are screened and validated through pilot-scale projects, which typically process at least one dry metric ton of feedstock per day. Funds through the American Recovery and Reinvestment Act (ARRA) have been invested in twelve pilot-scale biorefinery projects.
- **Demonstration-scale Projects:** After technologies have been validated at the pilot scale, they are scaled up to produce a minimum of 50 dry metric tons of feedstock per day (representing 1/50 to 1/10 of commercial scale). DOE has funded nine demonstration-scale projects (five through regular appropriations and four through ARRA) to further reduce technical and financial risks.
- **Commercial-scale Integrated Biorefineries:** These projects process a minimum of 700 dry metric tons of biomass per day to produce cost-effective biofuels, biopower, and bioproducts at a small commercial scale. DOE and industry are currently cost-sharing construction of six commercial-scale integrated biorefineries (one using ARRA funding) with the cumulative capacity to produce more than 100 million gallons of biofuels per year.

Photos courtesy of DOE/NREL

Pilot, Demonstration, and Commercial-scale Projects

Strategically locating biorefinery projects in different areas of the country promotes local and regional economic development and conversion technologies optimized for the biomass feedstocks in each region. Geographic diversity will also provide many areas of the nation with access to a domestic renewable energy supply as the private sector gains confidence in the technologies and scales up investment in new integrated biorefineries.

Integrated Biorefinery Project Locations



For the latest project information and details, please visit our website:

www.eere.energy.gov/biomass/integrated_biorefineries.html

Integrated Biorefinery Projects Receiving DOE Funds

Project	Location	Scale	Conversion Technology
Abengoa	Hugoton, KS	Commercial	Biochemical
Bluefire LLC	Fulton, MS	Commercial	Biochemical
Flambeau	Park Falls, WI	Commercial	Thermo - Gasification
Mascoma	Kinross, MI	Commercial	Biochemical
POET	Emmetsburg, IA	Commercial	Biochemical
Rangefuels	Soperton, GA	Commercial	Thermo - Gasification
Enerkem	Pontotoc, MS	Demonstration	Thermo - Gasification
INEOS New Planet Bioenergy LLC	Vero Beach, FL	Demonstration	Hybrid
Lignol	Washington	Demonstration	Biochemical
New Page	Wisconsin Rapids, WI	Demonstration	Thermo - Gasification
Pacific Ethanol	Boardman, OR	Demonstration	Biochemical
RSA	Old Town, ME	Demonstration	Biochemical
Sapphire Energy Inc.	Columbus, NM	Demonstration	Algae/CO_2
Verenium	Jennings, LA	Demonstration	Biochemical
Myriant	Lake Providence, LA	Demonstration	Biochemical
Algenol Biofuels Inc	Fort Myers, FL	Pilot	Algae/CO_2
American Process Inc.	Alpena, MI	Pilot	Biochemical
Amyris Biotechnologies Inc.	Emeryville, CA	Pilot	Biochemical
Archer Daniels Midland	Decatur, IL	Pilot	Biochemical
ClearFuels Technology	Commerce City, CO	Pilot	Thermo - Gasification
Haldor Topsoe Inc.	Des Plaines, IL	Pilot	Thermo - Gasification
ICM Inc.	St. Joseph, MO	Pilot	Biochemical
Logos Technologies	Visalia, CA	Pilot	Biochemical
Renewable Energy Institute International	Toledo, OH	Pilot	Thermo - Gasification
Solazyme Inc.	Riverside, PA	Pilot	Algae/Sugar
UOP LLC	Kapolei, HI	Pilot	Thermo - Pyrolysis
ZeaChem Inc.	Boardman, OR	Pilot	Hybrid

For additional information, visit **www.biomass.energy.gov.**

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