INEOS New Planet Bioenergy began production at its Indian River Bioenergy Center in Vero Beach, FL, in July 2013. Cost-shared funding from the Bioenergy Technologies Office contributed to the construction of this pioneer-scale plant, which converts waste biomass materials into 8 million gallons of cellulosic ethanol and produces 6 MW of power annually. *Photo: INEOS Bio*

# Integrated Biorefineries:
## Reducing Investment Risk in Novel Technology

Achieving national energy and climate goals will require a large, economically viable, and environmentally sustainable U.S. bioindustry. The U.S. goal to build a diverse, robust, and resilient energy sector creates an urgent need to bridge the gap between promising research and pioneering, large-scale production of advanced biofuels.

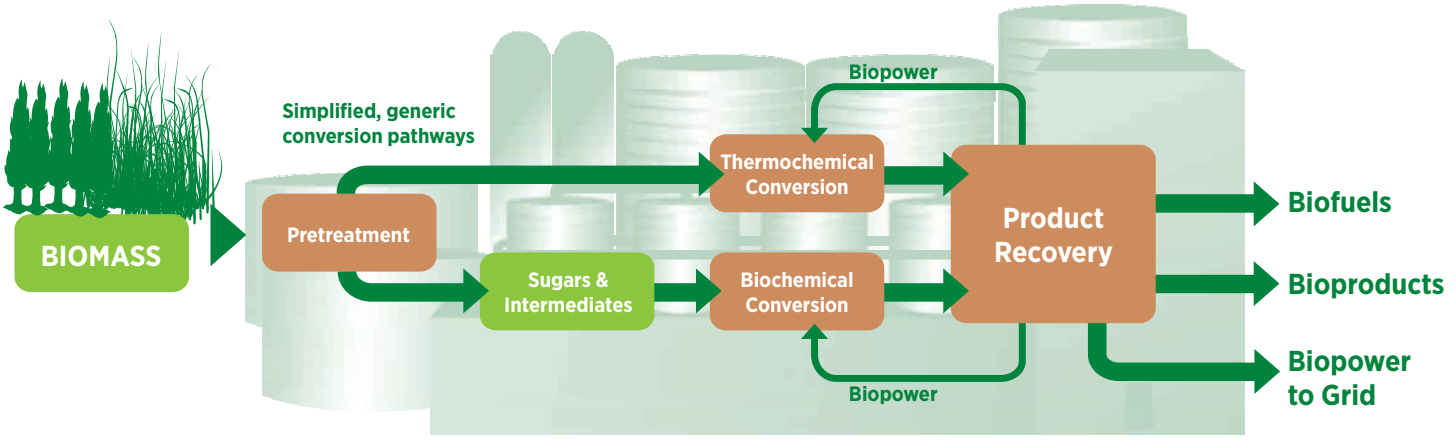
Developing the U.S. bioeconomy requires building many integrated biorefineries capable of converting a broad range of biomass feedstocks into affordable biofuels, bioproducts, and biopower. Integrated biorefineries are similar to conventional refineries in that they produce a range of products to optimize production economics and the use of feedstocks. The novel technologies needed to operate biorefineries require significant investments in research, development, demonstration, and deployment to reduce costs to a level competitive with fossil fuels.

The U.S. Department of Energy's Bioenergy Technologies Office works in partnership with industry to develop, build, and operate integrated biorefineries at various scales (pilot, demonstration, and pioneer). These projects are located around the country and use a range of non-food feedstocks and conversion technologies.

Federal support for these first-of-a-kind, integrated biorefineries is necessary to validate their performance and significantly reduce the technical and financial risks associated with new technology deployment. These investments support the goals of the *President's Climate Action Plan* and the national "all-of-the-above" strategy to develop diverse domestic energy sources—reducing costs to consumers, improving energy security, and maintaining our economic vitality.

> "Today's announcement of commercial-scale cellulosic production represents an important benchmark for American leadership in this growing global industry."
>
> *– Energy Secretary Ernest Moniz*
>
> *on the startup of the INEOS Bio facility, July 2013*

## Typical Conversion Pathways in Biorefineries




Researchers are exploring and improving a variety of conversion technologies to increase the efficiency and lower the cost of producing sustainable biofuels from diverse biomass feedstocks.

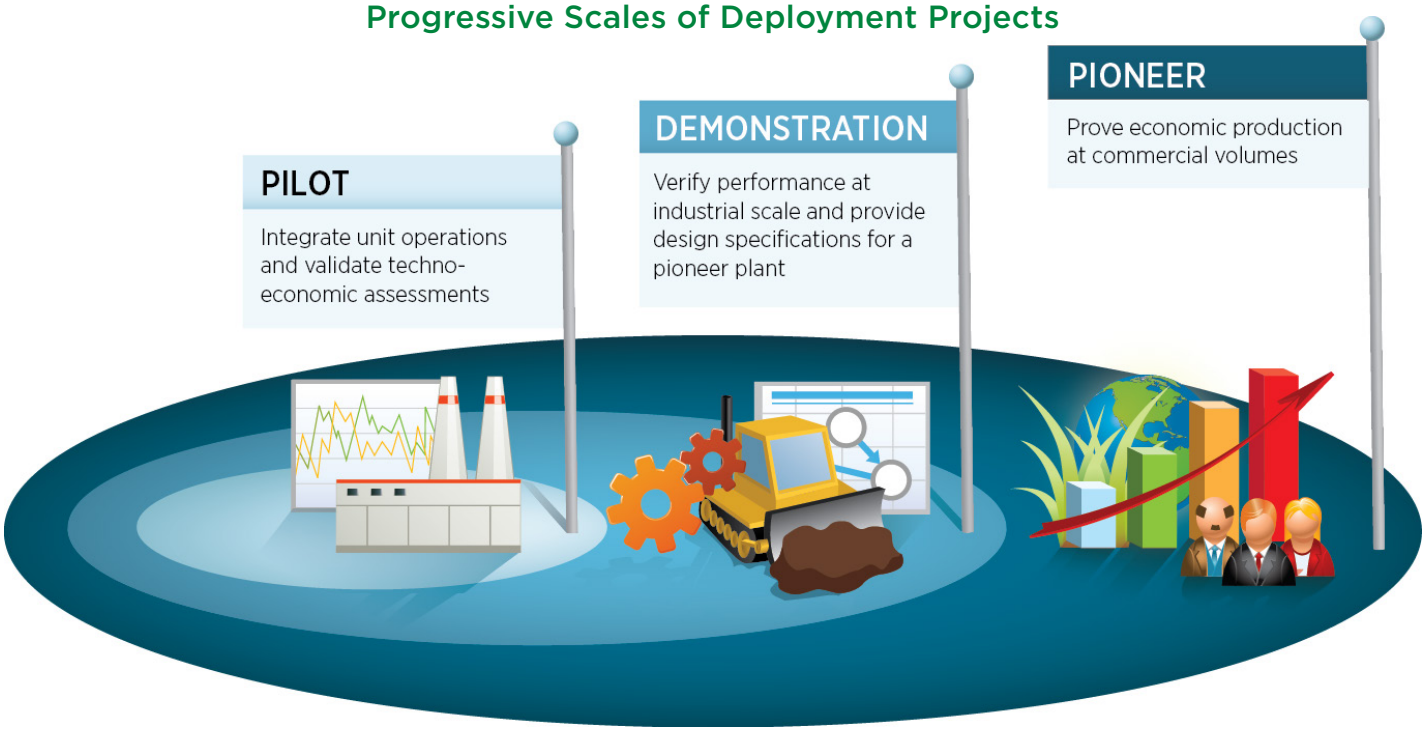
## Key Challenges:

The U.S. bioindustry faces diverse challenges.

- **Financing New Technologies:** Deployment and validation of new technologies and processes entail significant financial investment and technical risk. Financing can be particularly challenging for pilot-, demonstration-, and pioneer-scale projects that use innovative technologies and diverse feedstocks.
- **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 poses a challenge in developing replicable feedstock supply systems and conversion technologies.
- **Permitting:** To obtain proper permits, each biorefinery must establish community support and evaluate potential environmental impacts. This process can be complex as the specific conversion processes and feedstocks used in each biorefinery may have unique impacts on the environment.
- **Sustainability:** Economic, environmental, and social impacts must be carefully modeled and monitored on a life-cycle basis.
- **Consistent Research, Development, and Demonstration (RD&D) Investments:** Government, academia, and industry have made significant investments to develop the feedstock and biorefinery technologies needed to foster growth in the nascent bioeconomy. Many technologies in the early stages of development will need ongoing, consistent support if the nation is to meet its production goals for advanced biofuels.

The Energy Department provides cost sharing for pioneer biorefinery projects to help validate novel conversion processes and reduce the technical and financial risks to future investors. *Photo: NREL/01008*

## Progressive Scales of Deployment Projects




The Bioenergy Technologies Office provides cost-shared funding to industry partners to demonstrate promising conversion technologies and systems at progressive scales. Each scale builds upon the results of the prior stage.

## Integrated Biorefinery Deployment Activities:

The Bioenergy Technologies Office works through cost-shared public-private partnerships to address critical challenges in the deployment of integrated biorefineries. These biorefinery projects prove the viability of various feedstock and conversion pathways, typically following a progression from pilot through pioneer scale. Each step in this progression helps validate production performance, paving the way for commercial readiness.

- **Pilot Projects:** Promising technologies are screened and validated through pilot-scale projects, which typically process at least one dry metric ton of feedstock per day. These projects confirm energy balances, prove conversion efficiencies, and assess sustainability.
- **Demonstration Projects:** Successful demonstration projects verify technology performance and prove all recycle streams and products at a scale sufficient to provide the data and equipment specifications needed for projects 10 to 50 times larger. These projects provide valuable operational data to improve the designs and cost estimates for pioneer-scale facilities.
- **Pioneer Projects:** These first-of-a-kind facilities provide continuous, sustainable, and economical production at near-commercial volumes. The Department and industry are currently cost-sharing construction of several pioneer-scale integrated biorefineries.

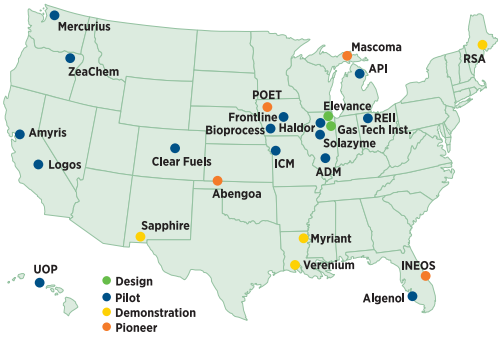
Novel technologies to increase the efficiency and lower the cost of biomass conversion are validated at the pilot scale. *Photo: REII*

Pioneer-scale biorefineries face many challenges in scaling up and integrating innovative technologies into profitable production systems. *Photo: POET*

## Geographic Diversity

Strategically locating biorefinery projects in different areas of the country promotes local and regional economic development and leads to 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 at *biofuels.energy.gov/integrated_biorefineries.html*.

## Integrated Biorefinery Projects

| Project | Location | Scale | Conversion Technology |
|---|---|---|---|
| Abengoa | Hugoton, KS | Pioneer | Biochemical |
| INEOS Bio/New Planet Bioenergy | Vero Beach, FL | Pioneer | Hybrid |
| Mascoma | Kinross, MI | Pioneer | Biochemical |
| POET/DSM Advanced Biofuels, LLC | Emmetsburg, IA | Pioneer | Biochemical |
| Myriant | Lake Providence, LA | Demo | Biochemical |
| Red Shield Acquisition, LLC (RSA) | Old Town, ME | Demo | Biochemical |
| Sapphire Energy, Inc. | Columbus, NM | Demo | Algae |
| Verenium* | Jennings, LA | Demo | Biochemcial |
| Algenol Biofuels, Inc | Fort Myers, FL | Pilot | Algae |
| American Process, Inc. (API) | Alpena, MI | Pilot | Biochemical |
| Amyris, Inc.* | Emeryville, CA | Pilot | Biochemical |
| Archer Daniels Midland (ADM) | Decatur, IL | Pilot | Biochemical |
| Bioprocess Algae | Shenandoah, IA | Pilot | Algae |
| Frontline | Ames, IA | Pilot | Gasification |
| Haldor Topsoe, Inc. | Des Plaines, IL | Pilot | Thermo - Gasification |
| ICM, Inc. | St. Joseph, MO | Pilot | Biochemical |
| Logos/Edeniq Technologies* | Visalia, CA | Pilot | Biochemical |
| Mercurius | Ferndale, WA | Pilot | Hybrid |
| Renewable Energy Institute International (REII) | Toledo, OH | Pilot | Thermo - Gasification |
| Rentech ClearFuels* | Commerce City, CO | Pilot | Thermo - Gasification |
| Solazyme, Inc. | Peoria, IL | Pilot | Algae |
| UOP, LLC | Kapolei, HI | Pilot | Thermo - Pyrolysis |
| ZeaChem, Inc. | Boardman, OR | Pilot | Thermo - Pyrolysis |
| Elevance* | Boilingbrook, IL | Design | Hybrid |
| Gas Technology Inst.* | Des Plaines, IL | Design | Thermo - Pyrolysis |

** Successfully completed*

### Learn More

*biofuels.energy.gov*

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

**For more information, visit:**
biofuels.energy.gov

DOE/EE-0912 • April 2014
Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.