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

Non-Hydrocarbon Energy Supply: Impact on Agriculture Industry

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Office Mission and Strategic Goals

The Mission and Key Goals of the Bioenergy Technologies Office (BETO) are as follows:

Mission

Develop and transform our renewable biomass resources into commercially viable, high-performance biofuels, bioproducts, and biopower through targeted research, development, demonstration, and deployment supported through public and private partnerships.

Goals

The goal of the Office is to develop commercially viable biomass utilization technologies to:

- Enable sustainable, nationwide production of advanced biofuels that are compatible with today's transportation infrastructure and can displace a share of petroleum-derived fuels to reduce U.S. dependence on oil
- Encourage the creation of a new domestic bioenergy industry supporting the Energy Independence and Security Act of 2007 goal of 36 billion gallons per year of renewable transportation fuels by 2022.

Bioenergy Technologies Office Overview

Cost Goals: Reduce the cost of biofuels to be competitive with petroleum-based fuels (gasoline, diesel, and jet fuels) in the market, reducing U.S. need for imported petroleum and reducing emissions from the transportation sector.

- By 2017, achieve a modeled cost of $3/gge for the pyrolysis pathway to drop-in renewable gasoline, diesel, and jet fuel.
- Develop additional pathways to enable utilization of a larger variety of biomass resources and conversion technologies that also aim to achieve $3/gge in 2022.

Research, Development, Demonstration, & Deployment

Feedstock Supply

Develop sustainable, secure, reliable, and affordable biomass feedstock supply

Conversion R&D

Develop commercially viable technologies for converting biomass feedstocks into fungible, liquid transportation fuels, bioproducts and chemical intermediates

Demonstration & Deployment

Demonstrate and validate integrated technologies with successful construction and operation of cost-shared pilot, demonstration, and commercial scale facilities

Cross-Cutting

Sustainability

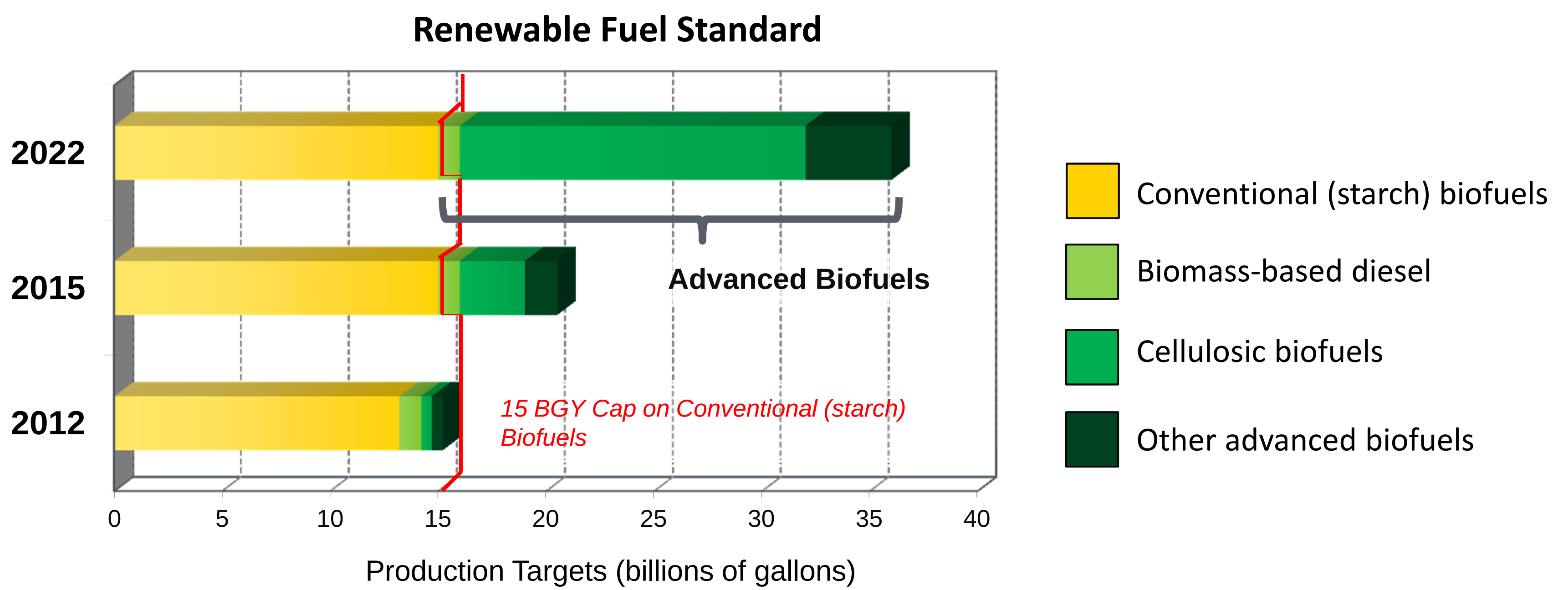
Promote the positive economic, social, and environmental effects, while reducing potential negative impacts of biofuels

Strategic Analysis

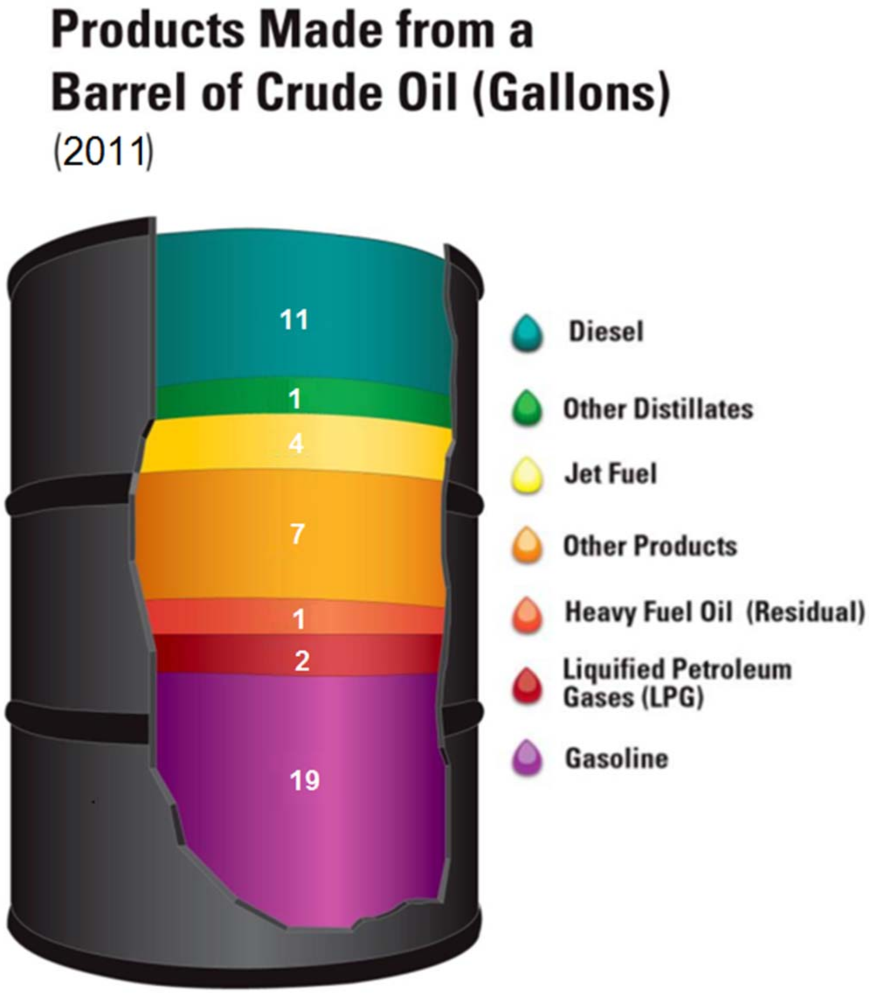
Provide context for decisions by establishing the basis of quantitative metrics, tracking progress toward goals, and informing portfolio planning and management

Key Policy Drivers – Renewable Fuel Standard

- The Renewable Fuel Standard (RFS) sets aggressive goals for the use of renewable fuels:
  - 36 billion gallons of renewable fuels by 2022; 21 billion gallons of advanced biofuels which reduce GHG emissions by 50 % relative to petroleum fuels
  - No more than 15 billion gallons of conventional corn-based ethanol
- Petroleum companies in the U.S. are required to meet minimum annual blending requirements or purchase credits for renewable fuels from other companies



Replacing the Whole Barrel



- Cellulosic ethanol only displaces gasoline fraction of a barrel of oil (about 40%).
- Reducing dependence on oil requires replacing diesel, jet, heavy distillates, and a range of other chemicals and products.
- Greater focus needed on RDD&D for a range of technologies to produce hydrocarbon fuels and displace the entire barrel of petroleum.

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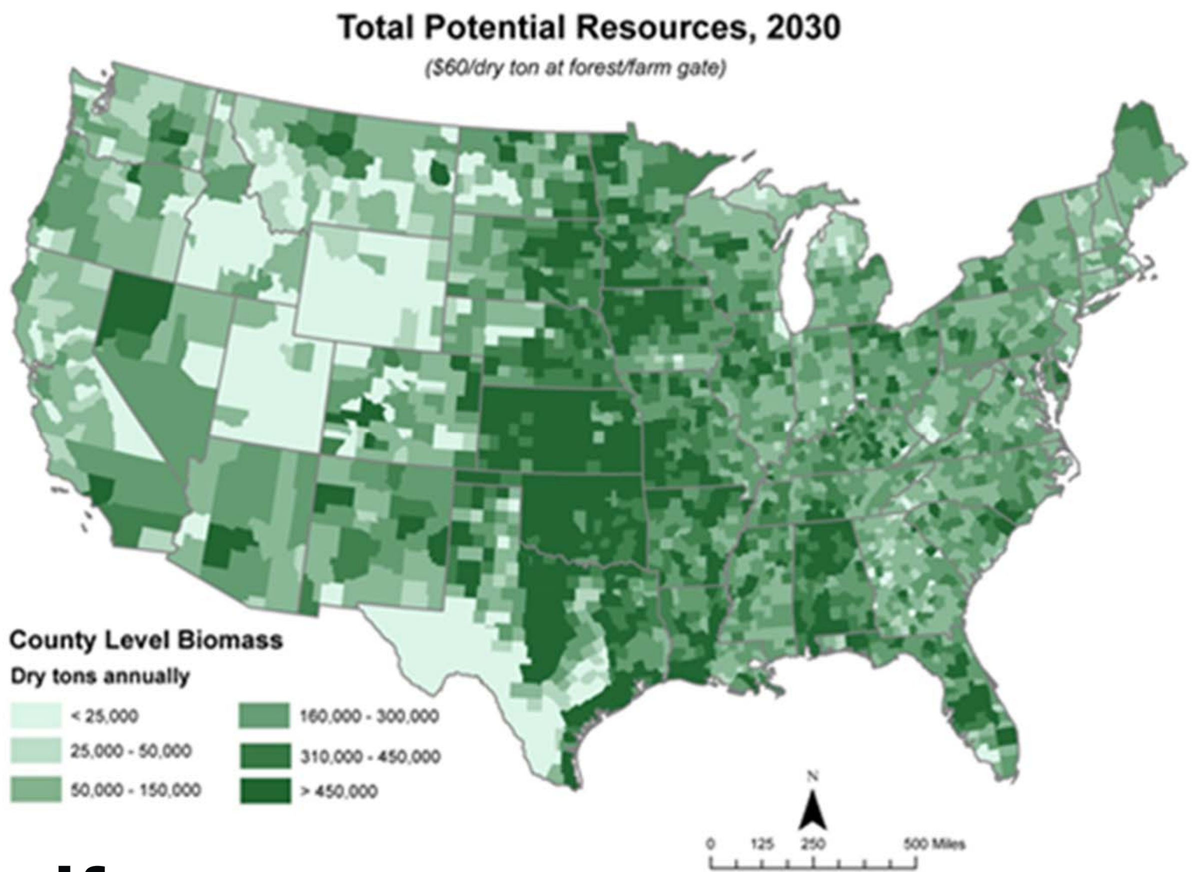
Biomass Resources Available in the U.S.

2011 Update to the Billion-ton Study

- DOE-funded resource assessment of all the major non-food biomass feedstocks produced in the U.S. under various scenarios out to 2030

Key Findings

- 1-1.6 billion annual dry tons of non-food biomass can be sustainably harvested by 2022, depending on the scenario
- Sufficient biomass resources to displace up to 30% of petroleum consumption in the U.S. (Not including algae)
- Data is publicly available on the Bioenergy Knowledge Discovery Framework



www.bioenergykdf.net

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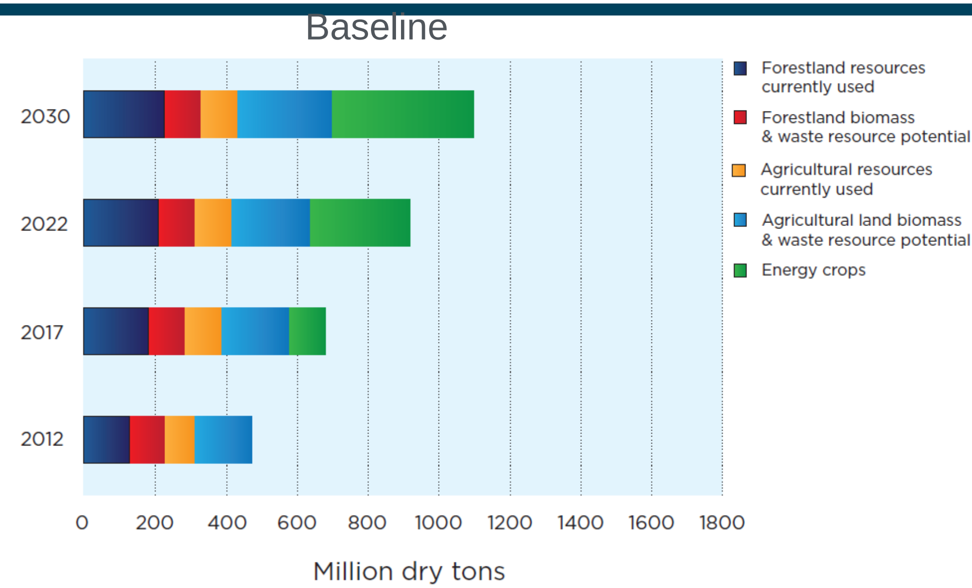
U.S. Billion-Ton Update: Findings

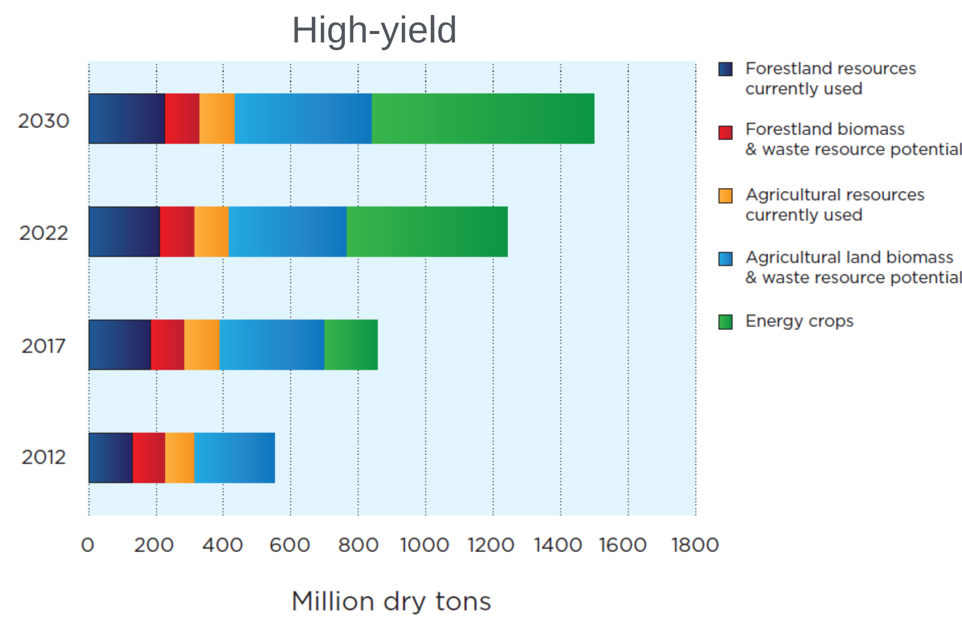
Baseline scenario

- Current combined resources from forests and agricultural lands total about 473 million dry tons at $60 per dry ton or less; about 200 million dry tons from forestry
- By 2030, estimated resources increase to nearly 1.1 billion dry tons; about 300 million dry tons from forestry

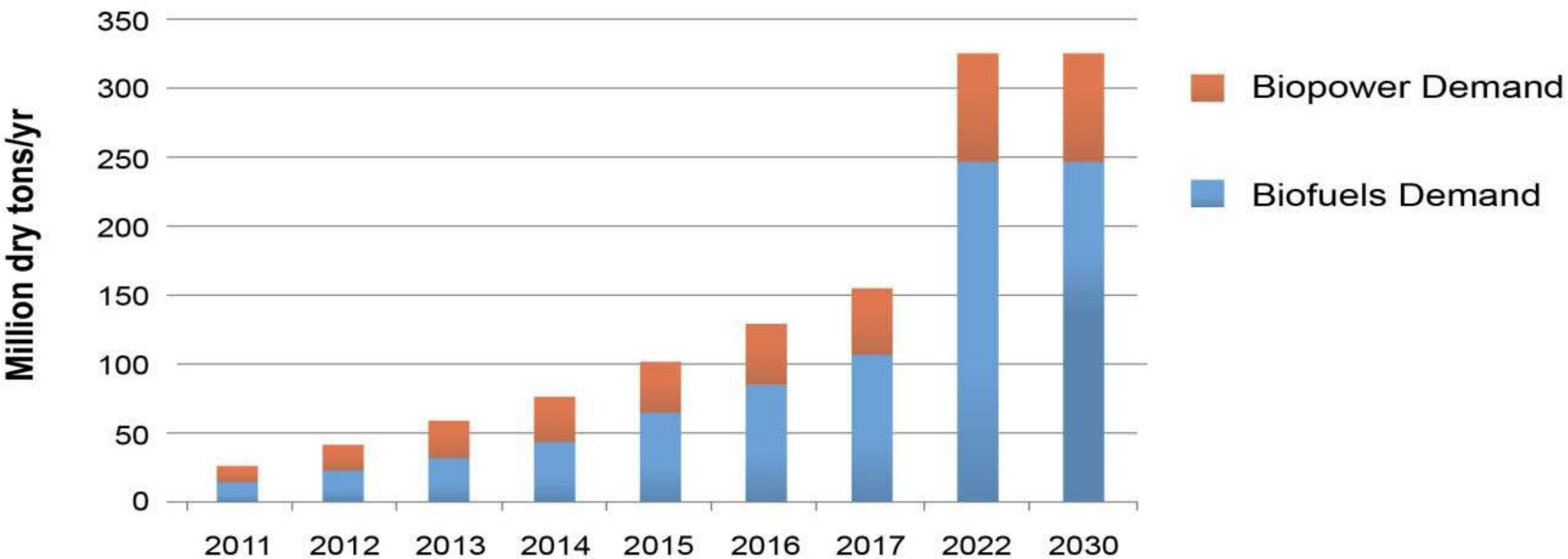
High-yield scenario

- Total resource ranges from nearly 1.4 to over 1.6 billion dry tons annually of which 80% is potentially additional biomass;
- No high-yield scenario was evaluated for forest resources, except for the woody crops



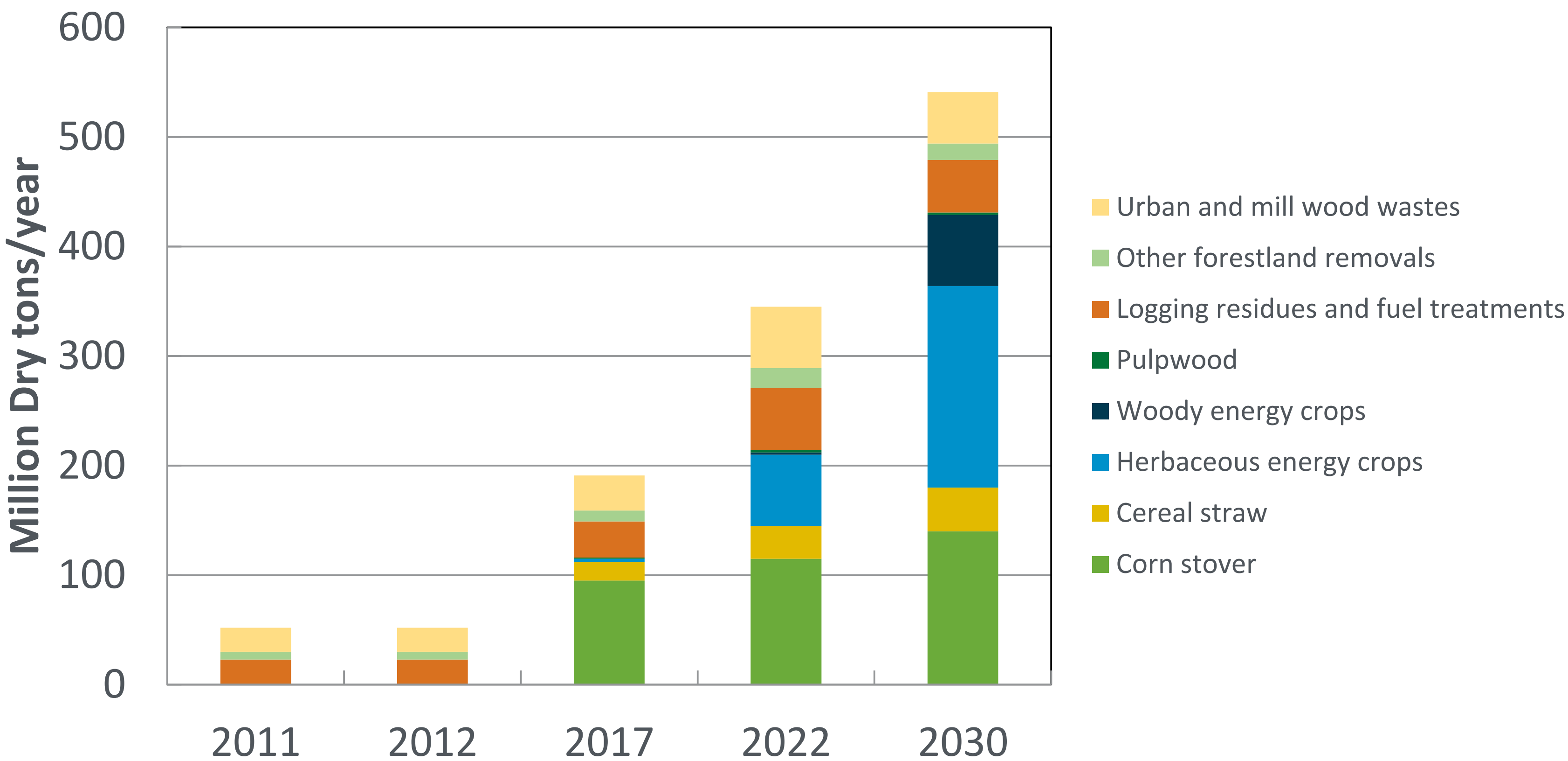


Projected Feedstock Demand



- 325 million tons/year of feedstock will be needed to meet RFS and biopower demands
- Biofuels demand calculated by assuming conversion efficiency of 85 gallons ethanol/bone dry ton
- Biopower demand based on EIA Annual Energy Outlook 2010. Electricity generation converted to feedstock demand assuming 13,000 Btu/kWh and 16 million Btu/dry ton

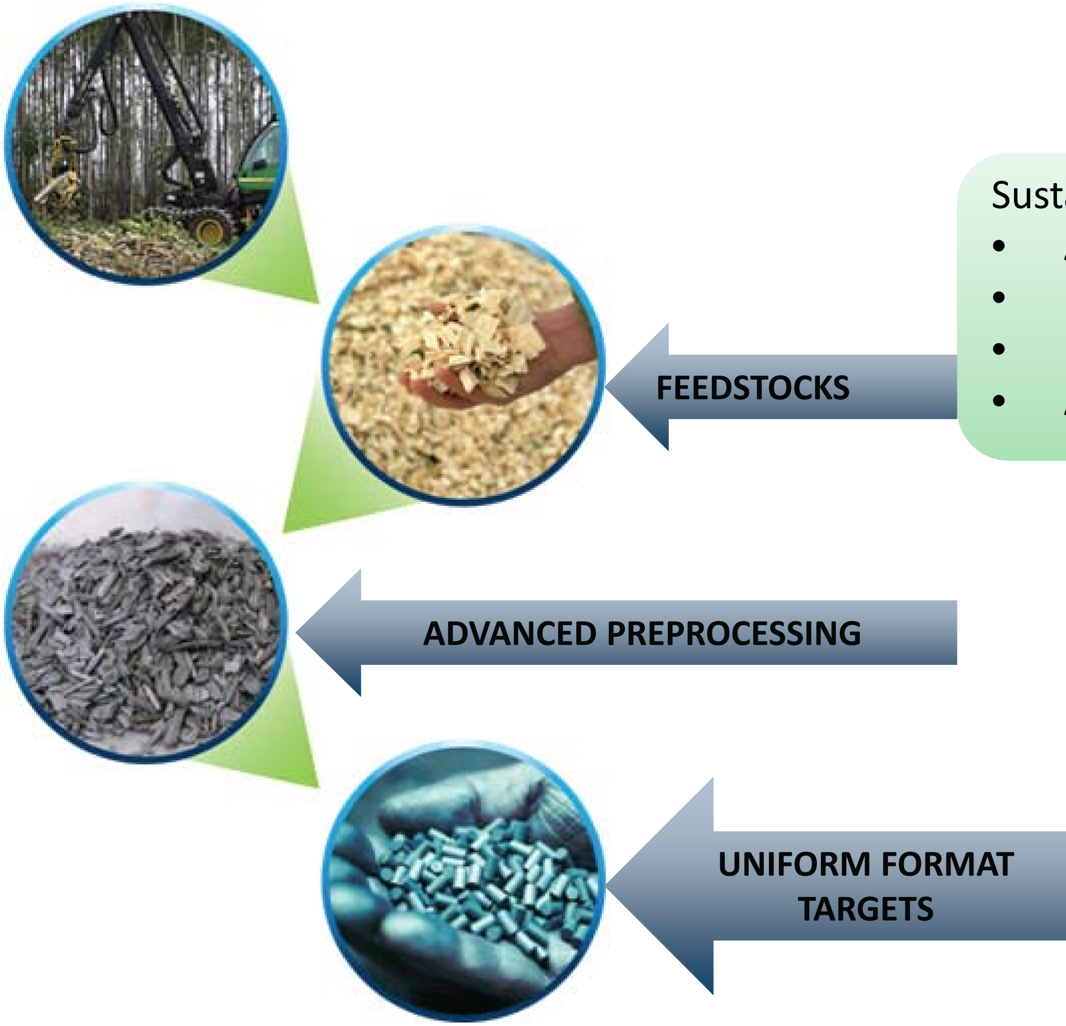
Projected Feedstock Availability



- 345 million tons/year of feedstock estimated to be available to meet RFS and biopower demands in 2022
- 540 million tons/year of feedstock estimated to be available in 2030
- Calculations using POLYSYS model assuming grower payments ranging from $14 to $48/dry ton

Sustainable Feedstock Supply

Feedstock supply efforts focus on RD&D to develop and optimize cost-effective, integrated systems for harvesting, collecting, storing, preprocessing, handling, and transporting.



Sustainable feedstocks include

- Agricultural residues
- Forest resources
- Dedicated energy crops
- Algae

A new uniform format advanced supply system design will improve the capacity and efficiency of each feedstock logistics unit operation

Current State of Feedstock Logistics

- Variety of ligno-cellulosic biomass sources could be used for energy production. They are unstable, bulky, heterogeneous, have poor flow properties and create logistics challenges.
- Current supply chain models locate the biorefinery near the feedstock resource (“conventional”) which minimizes transportation cost, example: corn stover
  - Biorefinery is vulnerable to supply chain upsets
  - Biomass resources are limited - stranded resources
  - Burden of variability is on biorefinery
  - Limited opportunity to address quality challenges
  - Limits biorefinery size
- Key Challenge: Biomass is not where it needs to be (dispersed, often remote) or what it needs to be (quality)
- Potential solution: Biomass commoditization

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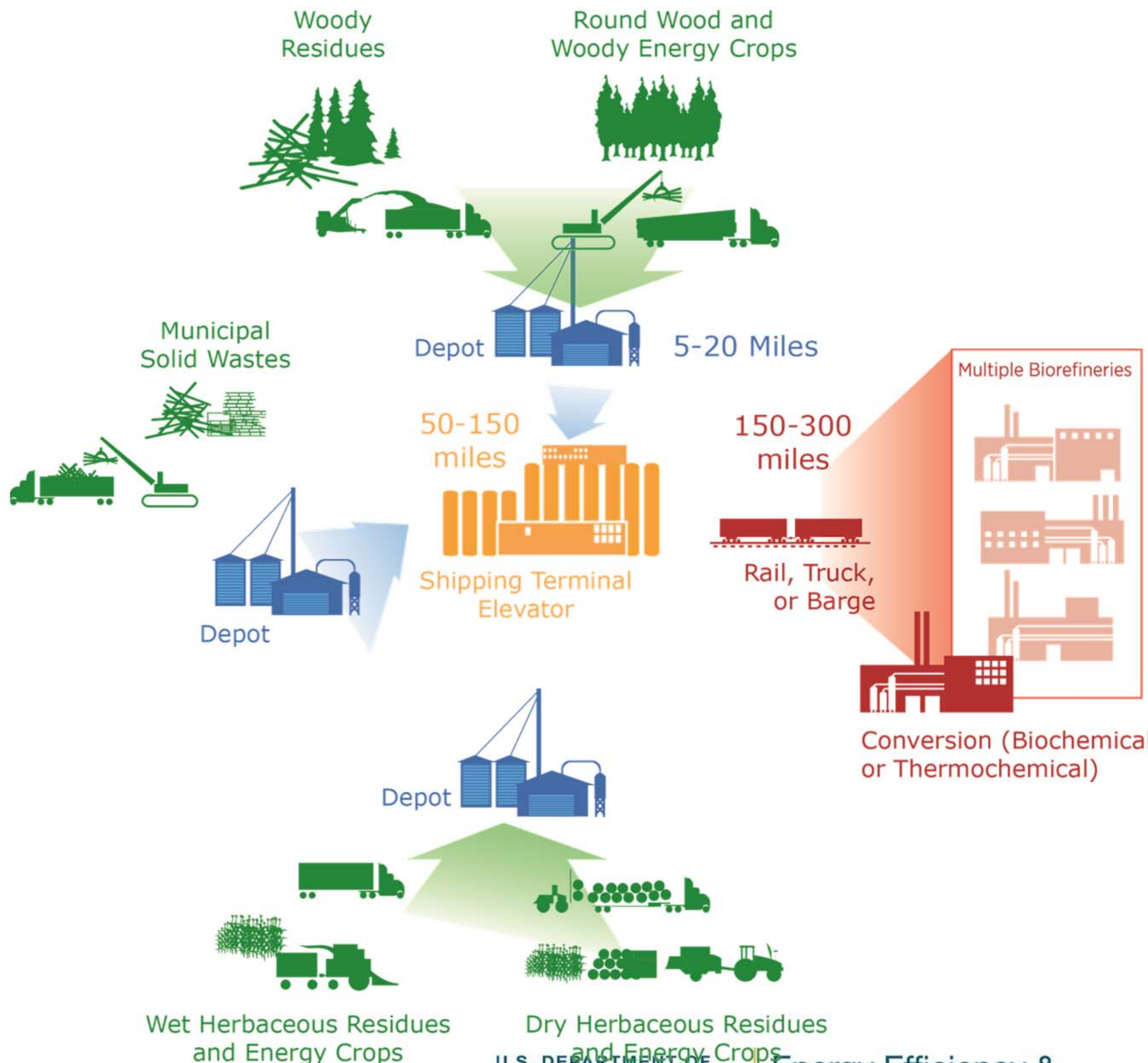
Uniform-Format Feedstocks - *Commodity Vision for Infrastructure Compatibility*

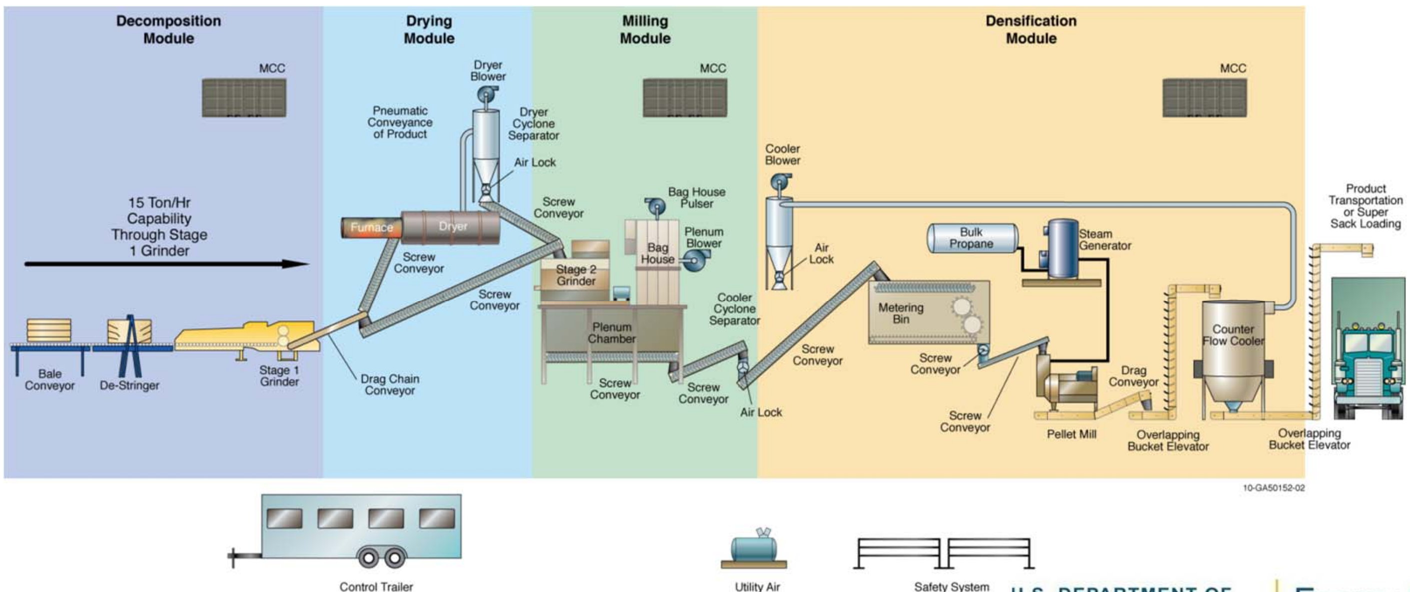
Commodity Attributes
Standardized material formats are compatible with existing solid and liquid supply handling systems and infrastructures
Feedstock quality is assured through national and international standards
National market systems secure supply and demand in a sustainable way
Biomass feedstocks futures contracts are tradable on commodity exchanges.

Infrastructure Boundaries (Solid System Example)
Production to Preprocessing Depot (5 to 20-mile radius) Field trucks
Preprocessing Depot to Terminal (50 to 150-mile radius) Interstate trucks, short line railroad, internal waterway transport systems
Terminal to Biorefineries (150 to 300+-mile radius) Trans/intercontinental shipping systems (e.g., unit trains, ocean barges, and freightliners)



One Research Tool: Idaho National Laboratory PDU

- Process Demonstration Unit (PDU) is a modular and reconfigurable biomass preprocessing system
- The design allows testing and comparing technologies in a fixed system
- The base configuration will uses existing technologies, allowing equipment to be swapped out or operated independently
- Modules are portable allowing deployment in any location with adequate space and available utilities



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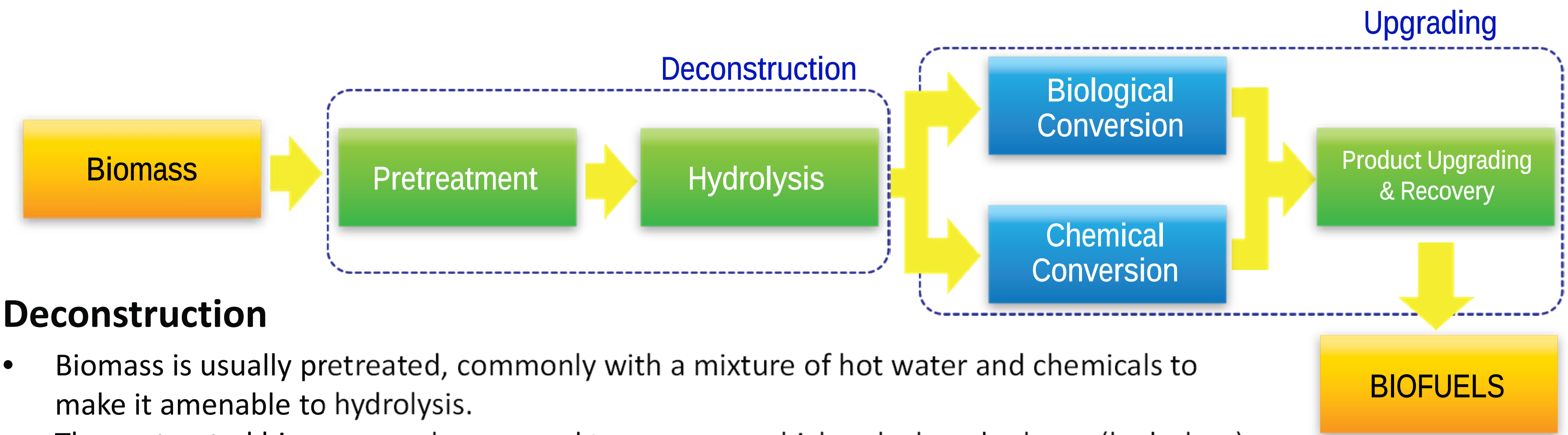
Biochemical Conversion

RD&D projects are improving the biochemical conversion of cellulosic biomass to biofuels and chemicals. These processing routes entail breaking down biomass to make the carbohydrates available for conversion into sugars that microorganisms and other catalysts can use to create biofuels and bioproducts.



Deconstruction

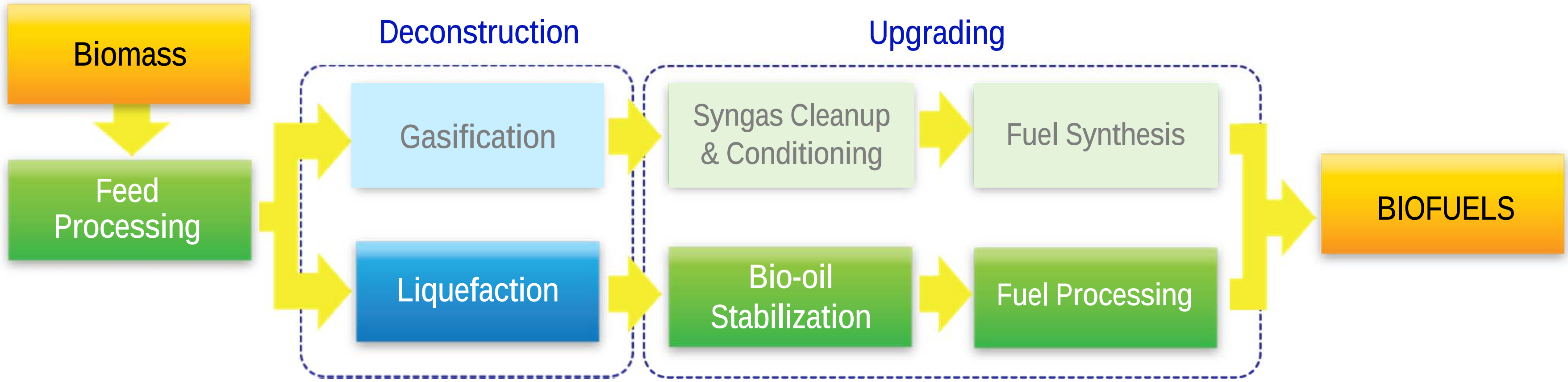
- Biomass is usually pretreated, commonly with a mixture of hot water and chemicals to make it amenable to hydrolysis.
- The pretreated biomass can be exposed to enzymes, which unlock and release (hydrolyze) the biomass sugars.
- Alternately, biomass can be completely deconstructed into sugar and carbohydrate streams using non-enzymatic processing technologies.

Upgrading

- The sugar-rich media is then fed to organisms, like yeast and E. Coli, which transform the sugars into biofuels and chemicals.
- Chemical catalysis can also be employed to transform the sugars into biofuels and chemicals.

Thermochemical Conversion

RD&D projects are improving the thermochemical conversion of cellulosic biomass. These processing routes use heat and chemistry to convert biomass into a liquid or gaseous intermediate, such as syngas or bio-oil. Customized processing of intermediates produces biopower or biofuels such as gasoline, diesel, and jet fuel.



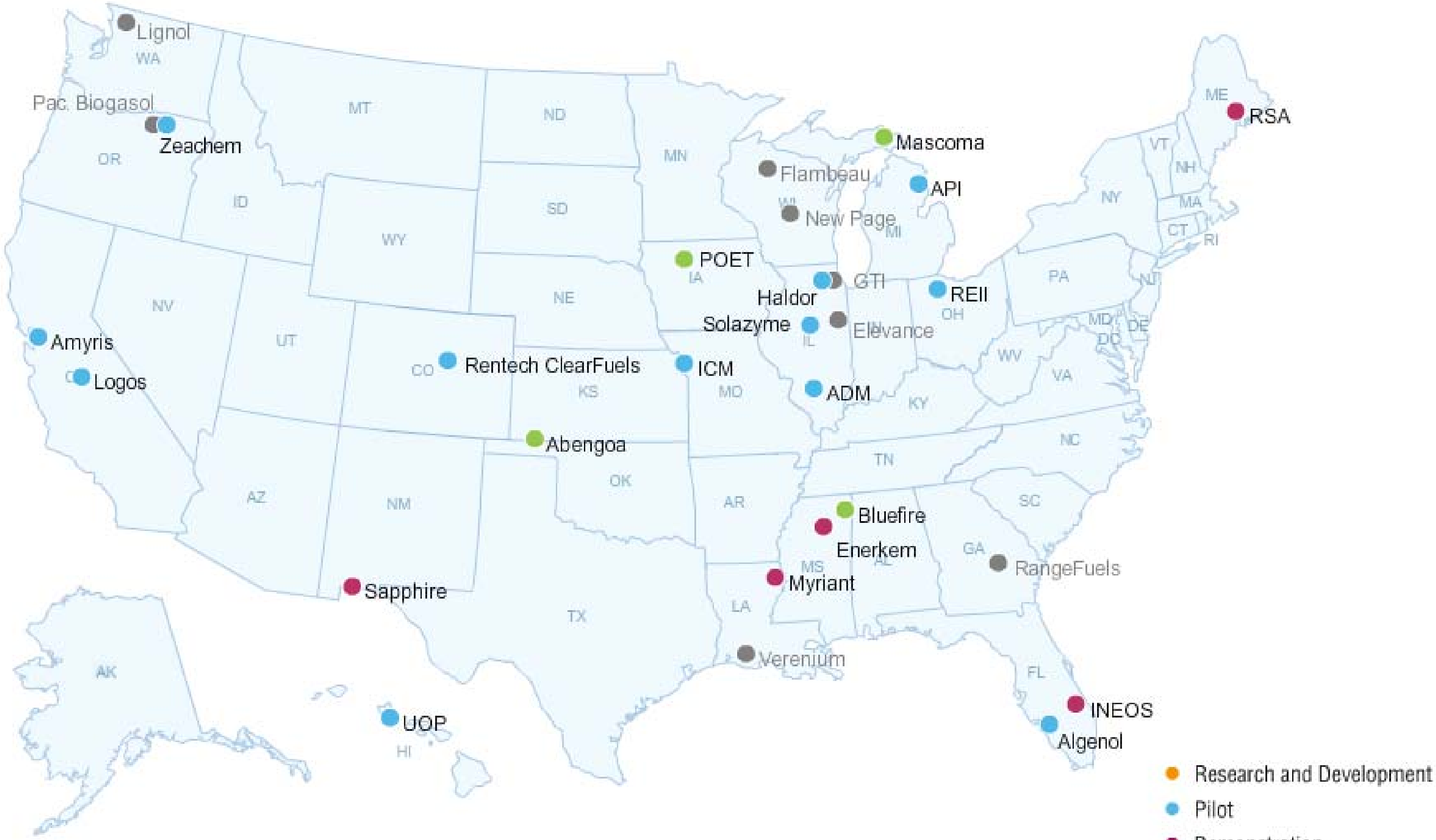
Deconstruction

- Ground and dried biomass is heated in reactors to produce gas, solid, and liquid intermediates.
- Gasification efforts are being de-emphasized after 2012 demonstration.

Upgrading

- Synthesis gas is cleaned (inorganics and CO_2 removal) and conditioned (tar reforming) and converted into biofuels and chemicals.
- Bio-oils are stabilized and upgraded (O_2 removal) to produce biofuels and chemicals.

Integrated Biorefinery Project Locations



Grey markers signify projects that are no longer active with the Bioenergy Technologies Office

http://www1.eere.energy.gov/bioenergy/integrated_biorefineries.html

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Analysis and Sustainability

Identifying and addressing the challenges for sustainable bioenergy production through field trials, applied research, capacity building, modeling, and analysis.

Agricultural Residues

Energy Crops

Forest Resources

Waste

Algae

Feedstock production and logistics

- Feedstock resource assessments
- Assess and reduce impact on land, water, climate, air quality, biodiversity, and resource use
- Increase landscape productivity

Conversion

- Techno-economic analysis of emerging biomass conversion pathways
- Minimize water consumption, GHG footprint, air pollution, and waste
- Maximize efficiency

ethanol

diesel

gasoline

jet fuel

biopower

bioproducts

End use

- Market analysis and industry growth scenarios
- Air quality impacts
- Avoiding negative impacts on human health

Cross-cutting

- Life-cycle analysis of water consumption and GHG emissions
- Supply chain environmental, economic, and social factors

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DPA Initiative Goals

- In June 2011, Secretaries of Agriculture, Energy, and Navy signed MOU to commit $510M ($170M from each agency) to produce hydrocarbon jet and diesel biofuels in the near-term. This initiative sought to achieve:
  - Multiple, commercial scale integrated biorefineries
  - Cost-competitive biofuel with conventional petroleum (w/o subsidies)
  - Domestically produced fuels from non-food feedstocks
  - Drop-in, fully compatible, MILSPEC fuels (F-76, JP-5, JP-8)

- DOD uses approximately 5 billion gallons of fuel annually and represents a key market adopter for advanced biofuels technologies

- Biorefineries selected under this initiative are expected to produce fuel for the "Great Green Fleet" demonstration in 2016

DPA Initiative – Accomplishments/Milestones

- This summer, four projects were selected and negotiated for Phase 1 awards with $20M from DOD funds. Phase 1 is an 18 month effort to accomplish front end engineering design, site selection, and commencement of permitting tasks.

- Successful projects will be selected to go on to Phase II construction if funds are available (early to mid FY 15 anticipated). There will be a down-select from four projects depending on availability of funds.
  - **Emerald Biofuels and Nature Bioreserve** - hydro-treating and upgrading of fats, oils and greases – mature technology, low risk.
  - **Fulcrum Brighton Biofuels** – MSW gasification followed by Fischer-Tropsch conversion to jet fuel is a higher risk technology demonstrating many of the high impact concepts within the DOE mission space.
  - **Red Rocks Biofuels, LLC** – forest biomass and wood wastes gasification followed by Fischer-Tropsch conversion to diesel and jet also represents a higher risk technology with greater potential for DOE involvement.

Recent Bioenergy Technologies Office Solicitations

Innovative Pilot and Demonstration Scale Production of Advanced Biofuels

- On April 22nd, the Department of Energy announced the four projects selected for negotiation for the innovative pilot FOA for the production of advanced biofuels. Each project that was selected will be working to produce biofuels that meet military specifications for jet and diesel fuel.

An F/A-18 Green Hornet Fighter plane operating on a 50/50 biofuels blend. Photo courtesy of the U.S. Navy.

- **Frontline Bioenergy LLCM, Ames, Iowa**
  - Up to $4.2 million to produce FT liquids from woody biomass, municipal solid waste, and refuse derived fuel. These liquids will be upgraded to produce samples of biofuels that meet military specifications.
- **Cobalt Technologies, Mountain View, California**
  - Up to $2.5 million to operate a pilot-scale integrated biorefinery to convert switchgrass to bio-jet fuel
- **Mercurius Biorefining, Inc., Ferndale, Washington**
  - Up to $4.6 million to operate a pilot plant converting cellulosic biomass into drop-in bio-jet fuel and chemicals.
- **BioProcess Algae, Shenandoah, Iowa**
  - Up to $6.4 million to produce hydrocarbon fuels meeting military specifications from an algae-based integrated biorefinery.

Aviation Biofuels Techno-Economic Analysis Workshop

When: November 27th, 2012 **Where:** Washington, DC

Workshop Objectives

- Benchmark current and future cost-of-production and performance characteristics of biomass-based processes that can produce jet fuel

Scope

- Processes
  - New pathways for aviation fuels
  - Biochemical conversion
  - Thermochemical conversion
  - Algae-derived methods
  - HEFA/HEFA algae
  - Gasification/FT
- Feedstocks
  - Productivity and handling

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Aviation Biofuels Workshop Summary

- Workshop provided a unique opportunity for stakeholders to discuss cost of biofuels production via multiple pathways.
- Challenge to make this knowledge accessible. Research results and data needs to be more broadly communicated; greater awareness of ongoing R&D is needed.
- As fuels are being qualified, costs should be considered. Fuel producers and key stakeholders should be brought into this process.
- Data from facilities under construction is difficult to obtain (IP, etc.), however, it is needed to provide a reality check.
- Common terms, units, and techniques are needed for techno-economic analysis to enable consistent comparison of technologies.
- Presentations at http://www1.eere.energy.gov/biomass/meetings.html, summary fact-sheet at http://www.caafi.org