

DOE Perspectives on Advanced Hydrocarbon-based Biofuels

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



U.S. Department of Energy
Office of Biomass Program
August 1, 2012

Zia Haq
DPA Coordinator
Advanced Biofuels Workshop



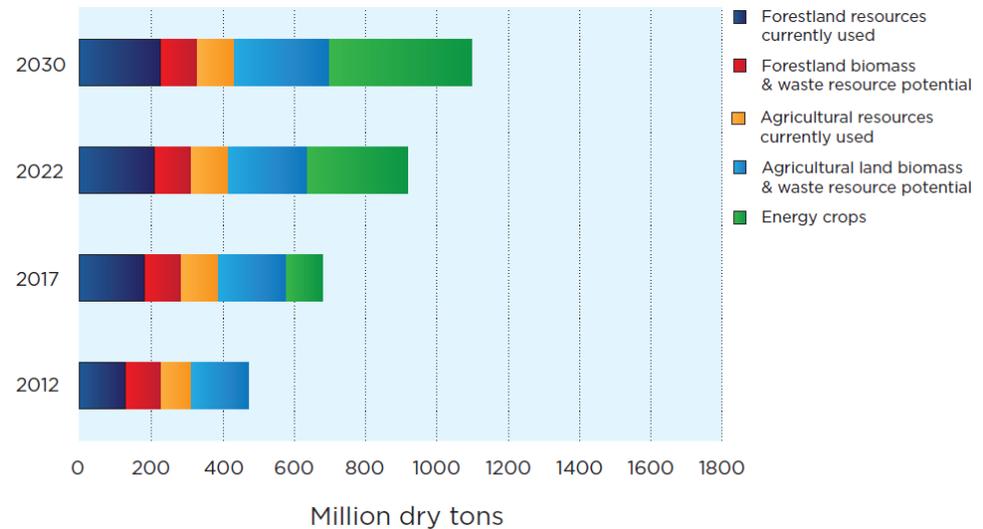
U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry

- Provides current and potential available biomass for 2012-2030
- Estimates are at the county level and for a range of costs to roadside
- Has scenarios based on crop yields and tillage practices
- Models land use for energy crops and ensures meet food, forage, and export commodity crop demands
- Includes sustainability criteria
- Report and data on the web

**Data and analysis tools located on the Knowledge
Discovery Framework: <http://bioenergykdf.net>**

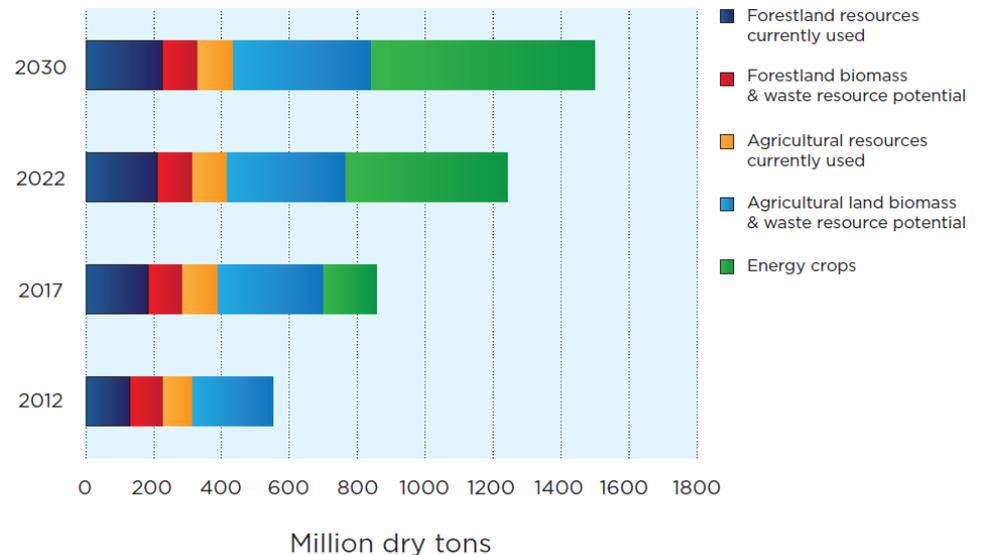
Baseline scenario

- 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



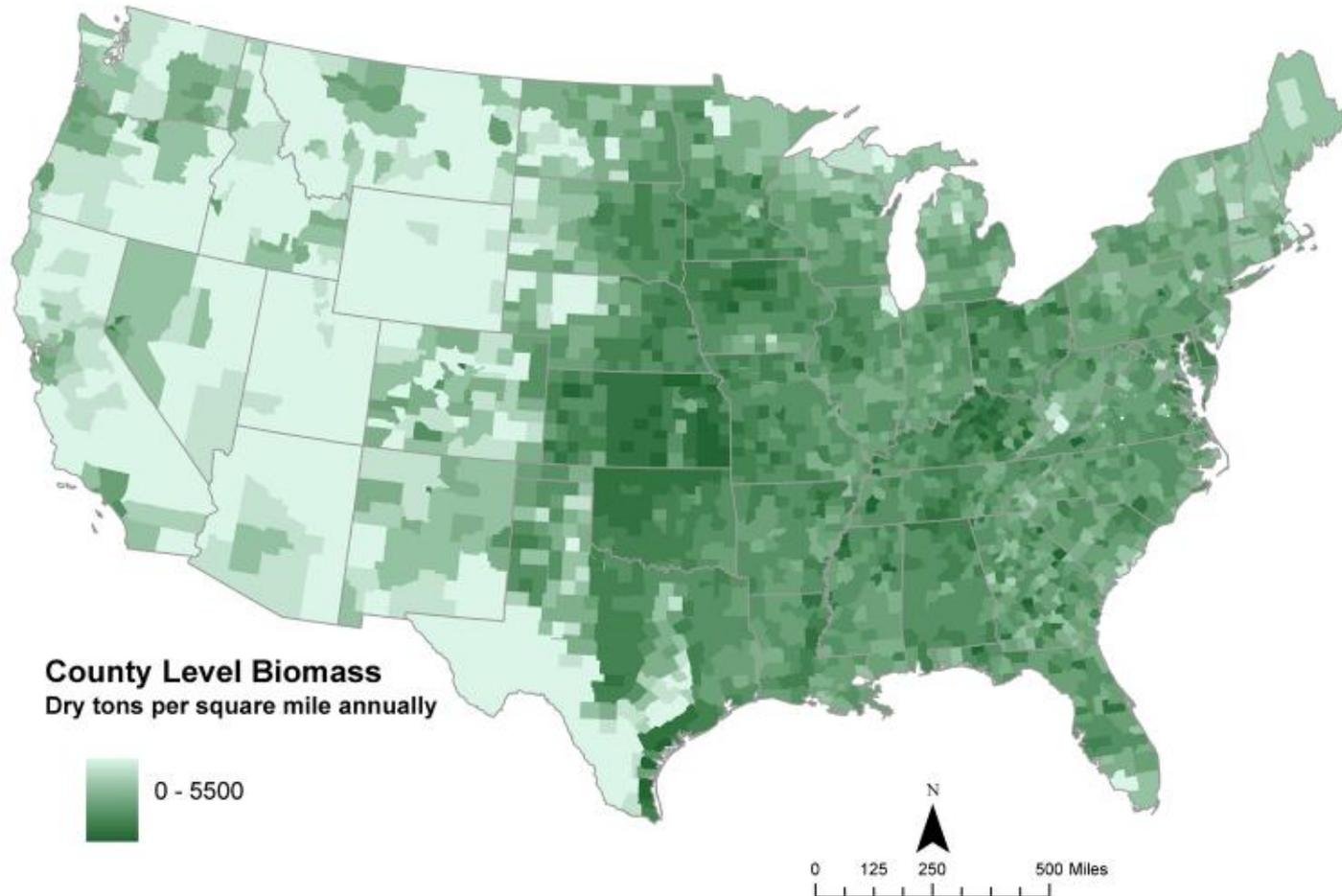
High-yield scenario

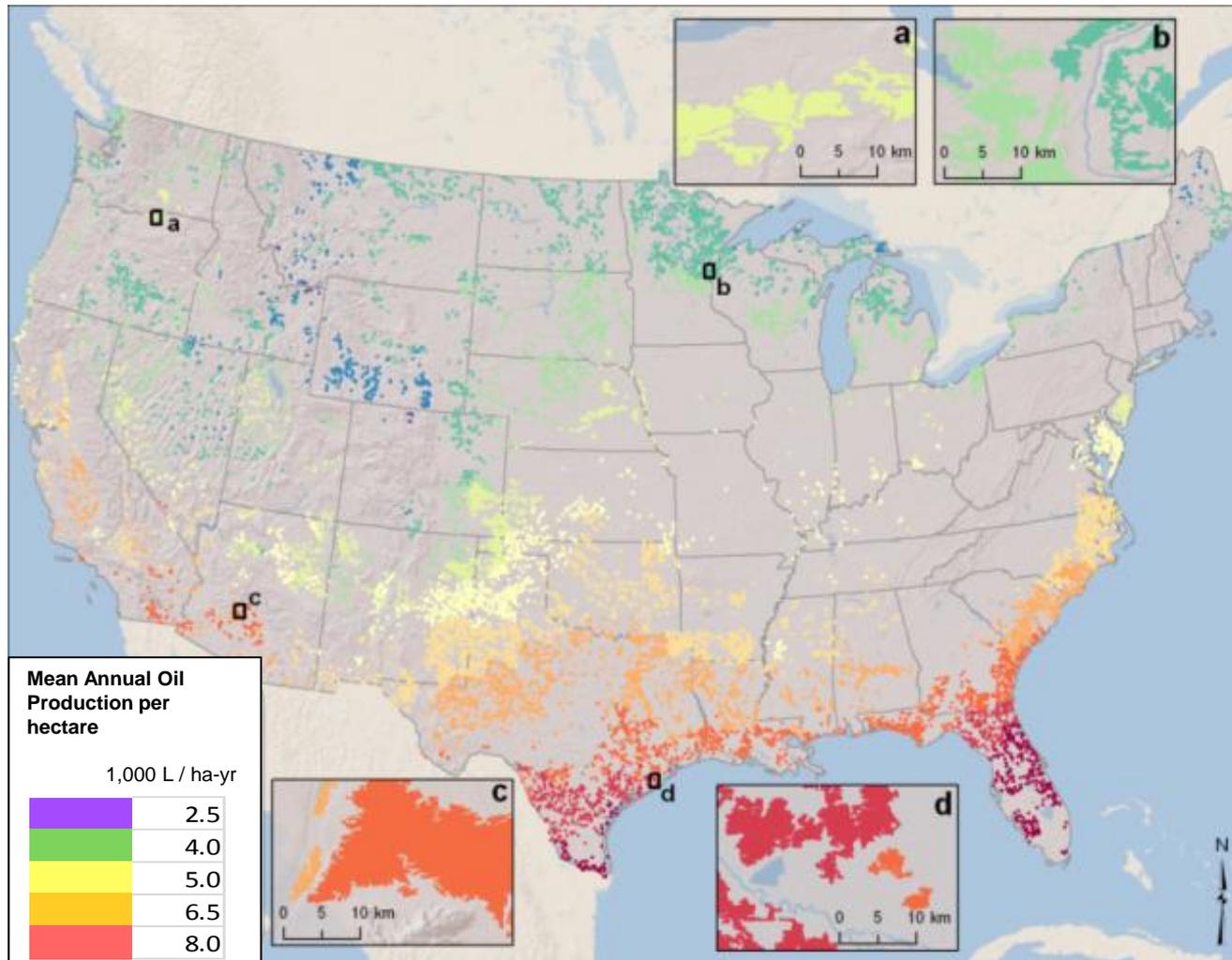
- Total resource ranges from nearly 1.4 to over 1.6 billion dry tons annually of which 80% is potentially additional biomass;
- No high-yield scenario was evaluated for forest resources, except for the woody crops



Potential County-level Resources at \$60 Per Dry Ton or Less in 2030

Under Baseline Assumptions





- A National resource assessment identified ~430,000 km² of suitable land for algae cultivation with potential for 58 BGY of algal oil production
- Optimizing to maximize productivity and minimize water use identifies 10,000 km², or about 3.7M acres, mainly around the Southwest and Gulf Coast
- These optimized sites would support production of 5 BGY

Wigmosta, M. S., A. M. Coleman, R. J. Skaggs, M. H. Huesemann, and L. J. Lane, 2011, National microalgae biofuel production potential and resource demand, *Water Resour. Res.*, 47, W00H04

IBR project investments will accelerate U.S. bio-industry growth and ramp up production of a range of biofuels and bioproducts.



A groundbreaking in February 2011 at the INEOS demonstration IBR.

Over \$1B in DOE investments in 29 IBR projects is helping bridge “Valley of Death”

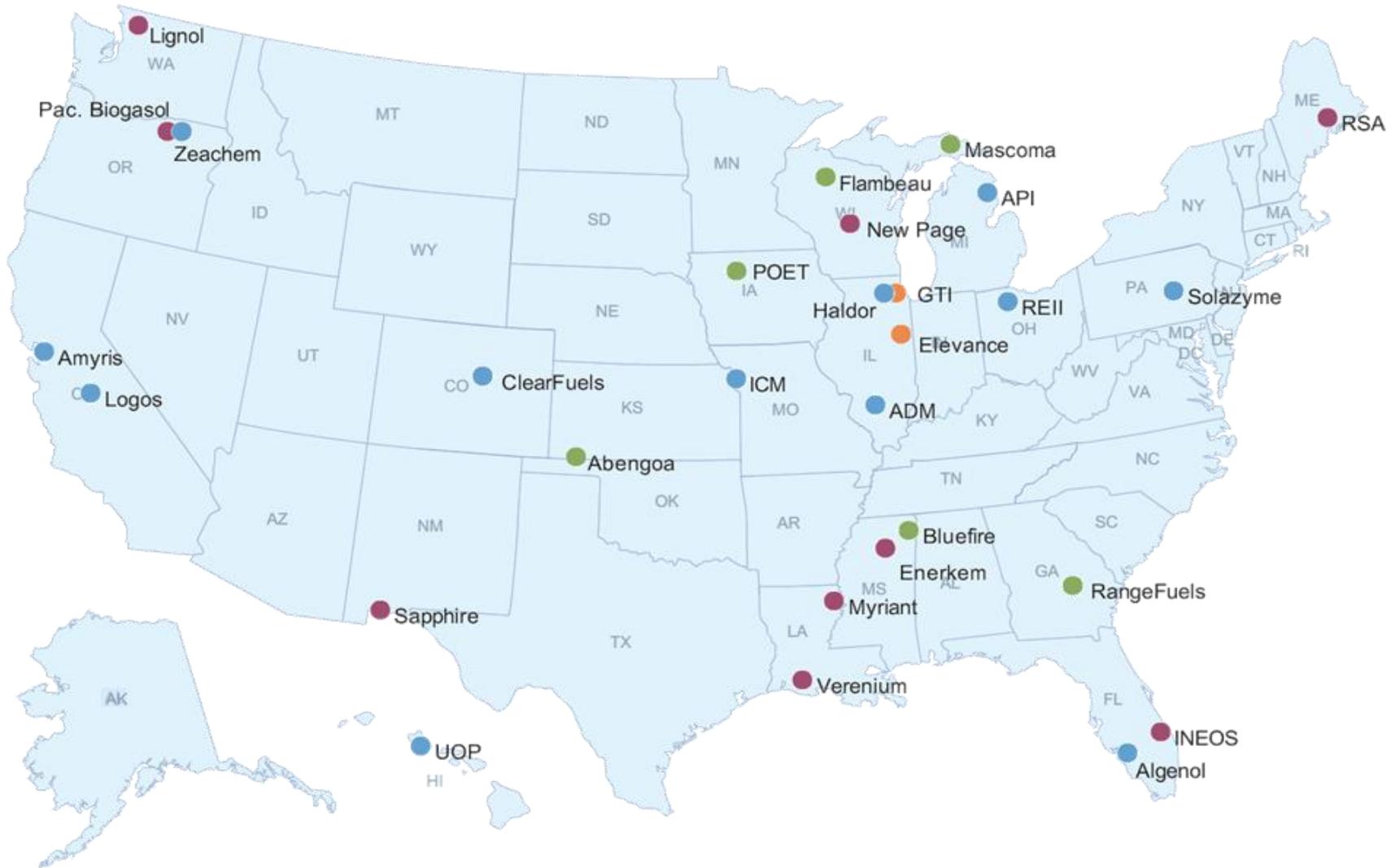
5 projects have received loan guarantees to build first-of-kind commercial facilities

At least 3 projects have IPOs that support their commercialization strategies

The successful first-of-kind facilities will allow for rapid replication and expansion of capacity

- Over \$1 billion Biomass Program investment is being cost shared with over \$1.7 billion from industry
- DOE investment has enabled equity investments, initial public offers (IPOs), venture capital (VC) funding, joint ventures (JVs), and joint development agreements (JDAs)

Integrated Biorefinery Locations



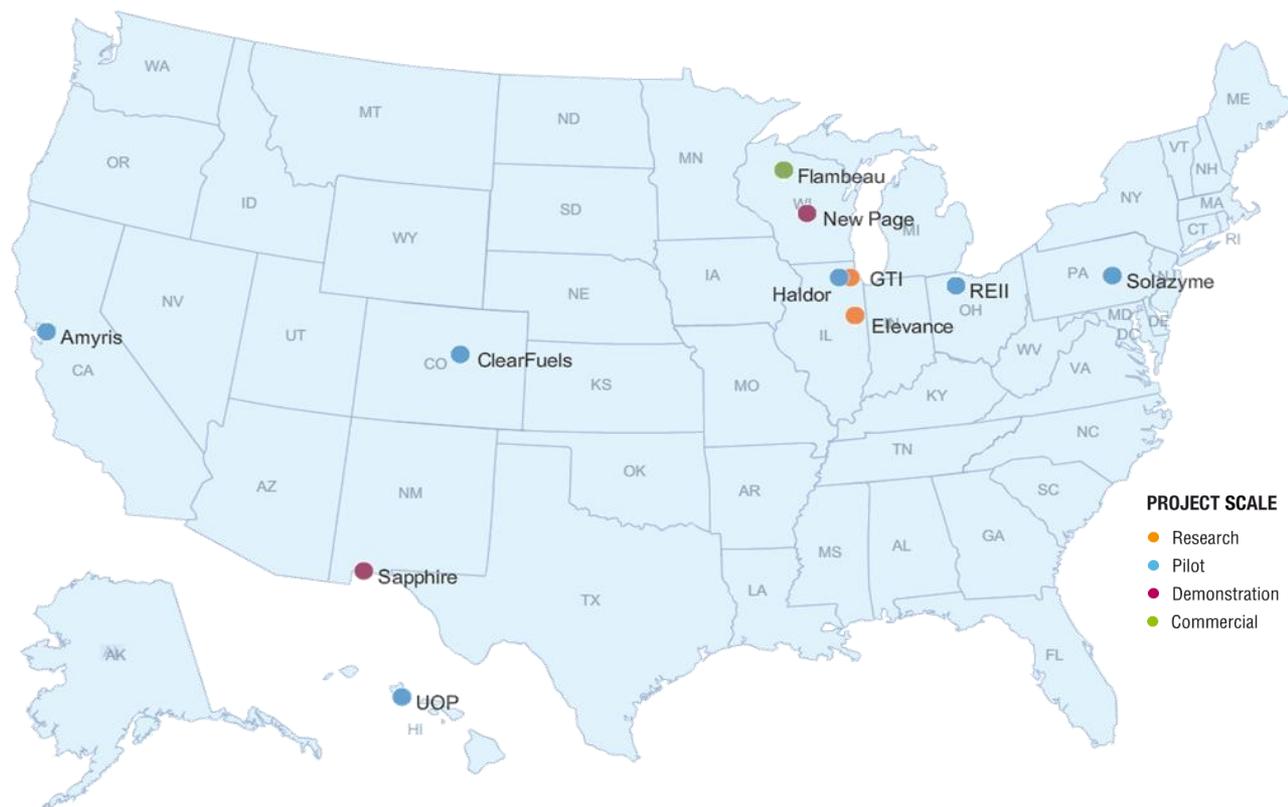
http://www.eere.energy.gov/biomass/integrated_biorefineries.html

DOE Biomass Program and Hydrocarbon Fuels

- 11 integrated biorefinery projects are investigating hydrocarbons from biomass resources:

Flambeau
New Page
Haldor
GTI
REII
Elevance
Solazyme
ClearFuels
Amyris
Sapphire
UOP

- GTI and Elevance are R&D projects.
- 9 projects are pilot, demonstration, or commercial scale.



For more information visit:

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

- Technology platforms leading to commercialization
 - Retrofit iso-butanol conversion (Butamax, Gevo)
 - Cellulosic ethanol bolt-on (POET-DSM, Abengoa)
 - Natural gas to liquids (Sundrop Fuels, Coskata)
 - Renewable diesel utilizing hydrotreating of animal residues (Neste Oil, Diamond Green Diesel)
 - Thermo-catalytic conversion of wood chips into hydrocarbon fuels (KiOR, Rentech, Ensyn/Envergent)
 - Advanced fermentation using engineered organisms (LS9, Algenol)
- Feedstock trends – Already aggregated feedstock or already in existence and easy to aggregate (corn starch, corn cobs, stover, existing wood basket, animal residues, natural gas).
- Novel feedstocks (energy grasses, cane) are small scale and longer term.

Source: Biofuels Digest, “Which Biofuels Players Are Getting Traction Now?”
<http://www.biofuelsdigest.com>, July 30, 2012

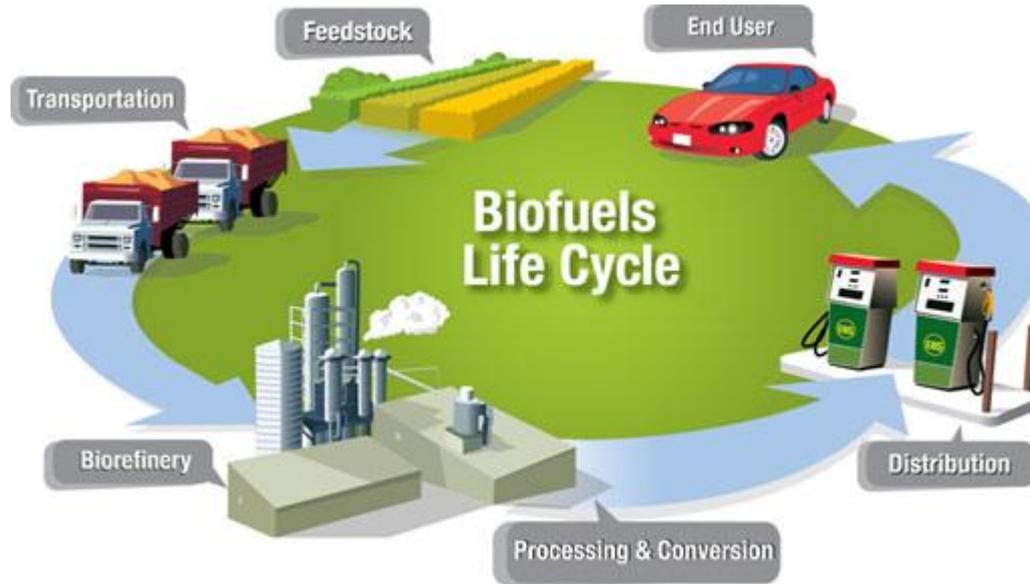
- **President Obama:** DOE + USDA + Navy to collaborate with the private sector to initiate “drop-in” biofuels industry to meet the transportation needs of DoD and the private sector
- **DOE, USDA & Navy:** MOU signed by Secretary Chu, Vilsack, and Mabus to support sustainable, commercial-scale biorefineries to produce hydrocarbon jet and diesel biofuels in the near-term
- **Construct / retrofit several “Pioneer” Biorefineries:**
 - Drop-in hydrocarbon biofuels meeting military specifications
 - Geographically diverse locations to enable market access
 - No adverse impact on food / feed supplies
 - Demonstrate commercial viability to encourage private-sector investment
 - Utilize Defense Production Act (DPA) for flexible joint funding and spending
- **Integrated Product Team (IPT) comprised of personnel from DOE, USDA, and DoD has been established:**
 - Objective is to write RFI, FOA, and review proposals
 - RFI issued August 2011, FOA open, close date August 13, 2012

- Objective – Production of hydrocarbon fuels at pilot or demonstration scale facilities that meet military blend fuel specifications. Two topic areas will be supported:
 - Technologies that utilize algae (micro, macro, cyanobacteria, heterotrophic)
 - Technologies that utilize ligno-cellulosic biomass and other waste feedstocks
- The innovative pilot FOA will:
 - Enable the production of hydrocarbon blendstocks at pilot or demonstration scales – JP-5 (jet fuel primarily for the Navy), JP-8 (jet fuel primarily for the Air Force, or F-76 (diesel))
 - Lead to better understanding of the cost of production, fuel characteristics, and emissions impacts of biofuels

Planning and progress assessments, defining and validating performance targets for biomass technologies and systems, reviewing and evaluating external analysis and studies, and contributing engineering analyses

State-of-technology assessments conducted by INL, NREL, ORNL, PNNL, SNL

Land-use change model development conducted by ANL, NREL, ORNL, PNNL, Purdue Univ. and Univ. of Minnesota



GIS-based assessment of algal resource potential conducted by PNNL

Well-to-wheels analysis and expansion of GHG Emissions and Energy Use in Transportation (GREET) model for emerging biofuels production pathways conducted by ANL

- Open Fuels Standard Act of 2011 – S.1603 (Sen. Cantwell, and H.R. 1687 (Shimkus, Engel, Bartlett, Israel)
- S. 1603 - Minimum 50% “fuel choice enabling vehicles” by 2015, 2016, 2017
- Minimum 80% “fuel choice enabling vehicles” by 2018 and beyond
- “Fuel choice enabling vehicle” – E85, Methanol, Biodiesel, natural gas, hydrogen, electricity, hybrid electric vehicle
- Supported by RFA and other organizations. Led by Gal Luft, James Woolsey, and others.
- Information available at <http://www.openfuelstandard.org>