

Thermal Gasification of Biomass United States Update

IEA Bioenergy Task 33

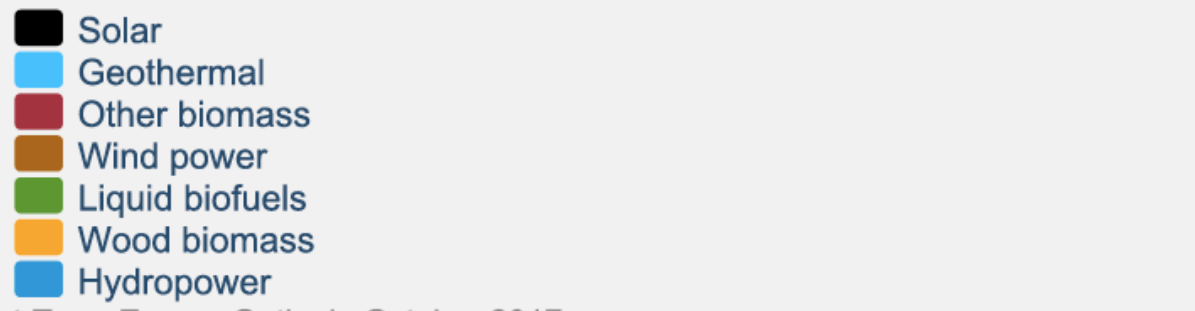
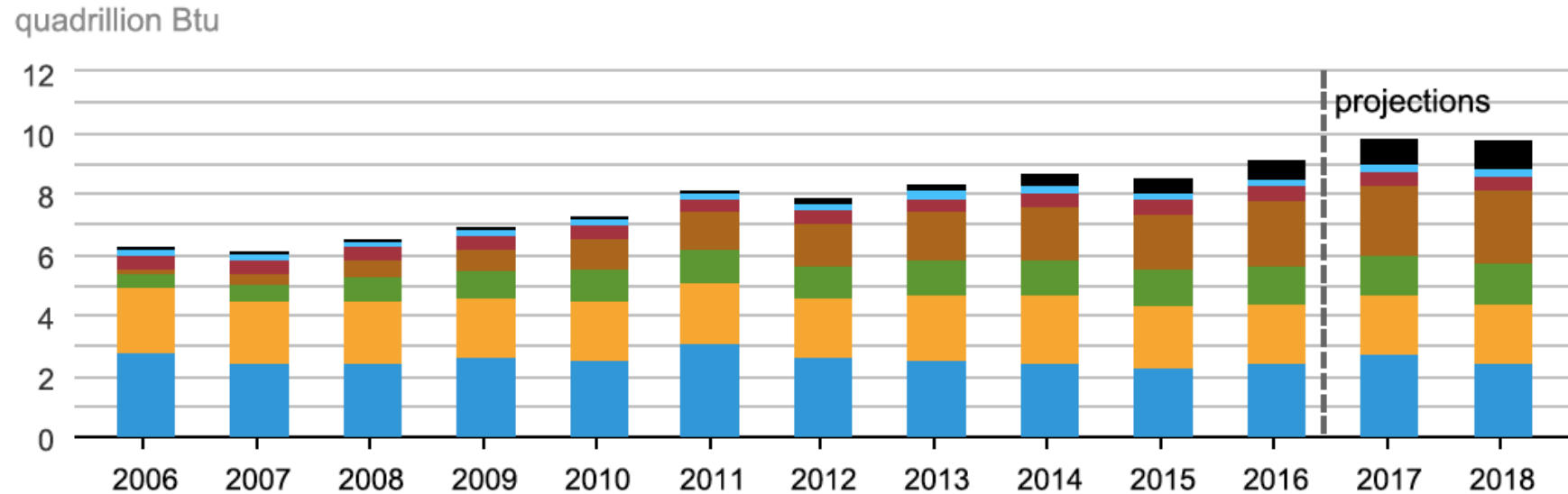
First Semiannual Task Meeting 2017

Skive, Denmark

23 October 2017

Kevin Whitty

Renewable Energy in USA

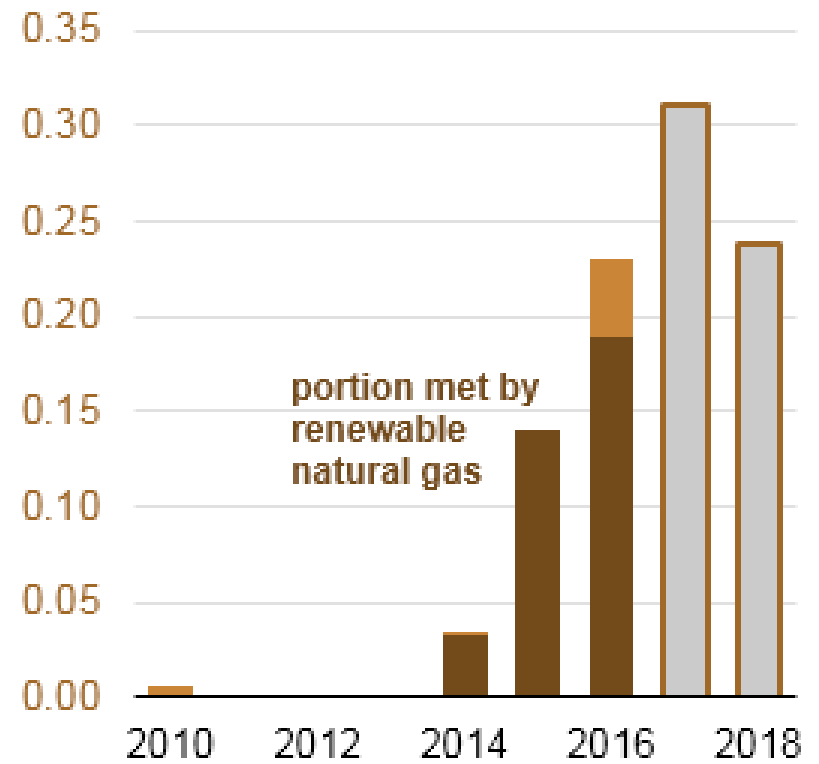
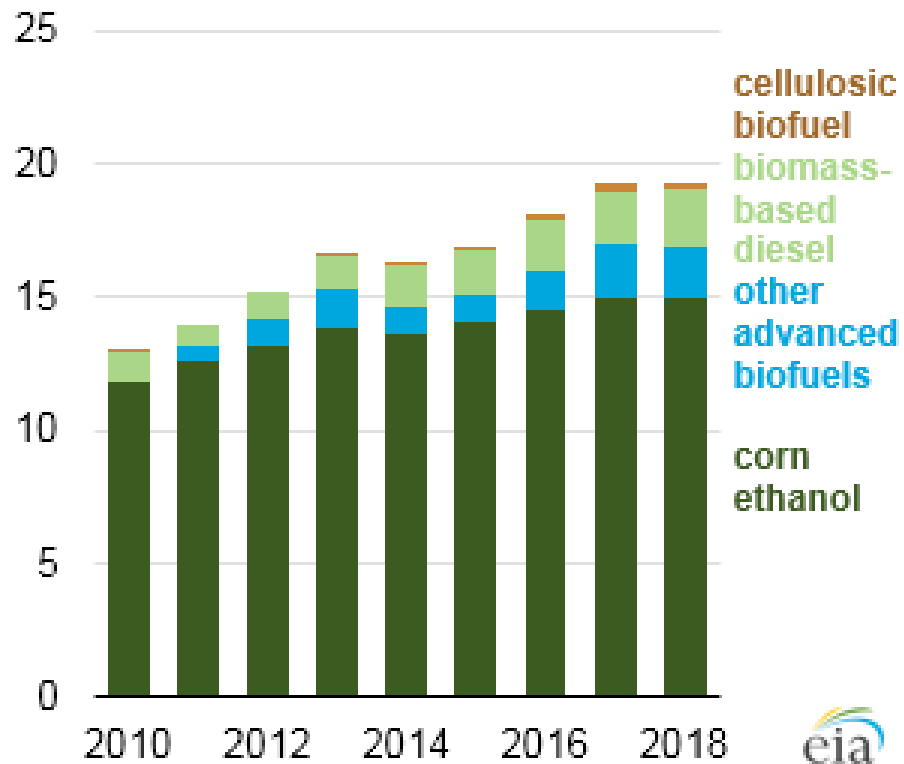


Source: Short-Term Energy Outlook, October 2017

Note: Hydropower excludes pumped storage generation. Liquid biofuels include ethanol and biodiesel. Other biomass includes municipal waste from biogenic sources, landfill gas, and other non-wood waste.

Biofuels

(billion gallons, ethanol equivalent)



Gasification Update – U.S. DOE BETO

- DOE-supported research projects
 - September 2017: Thermochemical Recovery International (TRI) will study and improve feedstock and residual solids handling systems targeted to commercial pyrolysis and gasification reactors. TRI's work in these systems will promote feedstock flexibility and enable the processing of low-cost feedstock to enhance IBRs' economic viability.
- DOE-supported gasification-based biorefineries
 - Fulcrum Bioenergy – Sierra Biofuels Plant
 - Red Rocks Bioenergy

U.S. DOE Biomass Energy Technology Office (BETO) Updates

- Budget for FY 2016 was \$225 million.
- Requested \$279 million for FY 2017. Budget became \$225 million
- Requested \$57 million for FY 2018 (75% reduction)
 - Conversion technologies \$86 million to \$35 million
 - Algae program \$30 million to \$5 million
- Continued support for demonstration plants
 - Fulcrum Bioenergy
 - Red Rock Biofuels
 - Emerald Biofuels

Fulcrum Bioenergy

Sierra Biofuels Plant, Reno, Nevada

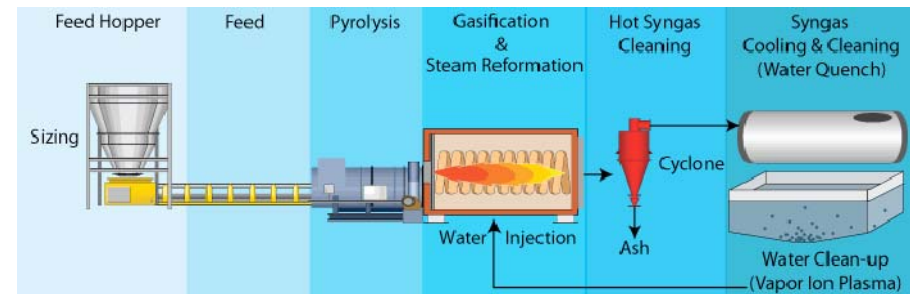
- Waste to FT fuels
- 200,000 t/y MSW
- 10 million gallons syncrude
- TRI gasifier
- \$30 million investment by BP
- Collaboration with Tesoro
- Offtake agreements with United Airlines, Cathay Pacific, Air BP
- Feedstock processing facility built and operational
- Currently finalizing private investment
- **No new news in past 12 months**



Red Rock Biofuels

Lakeview, Oregon

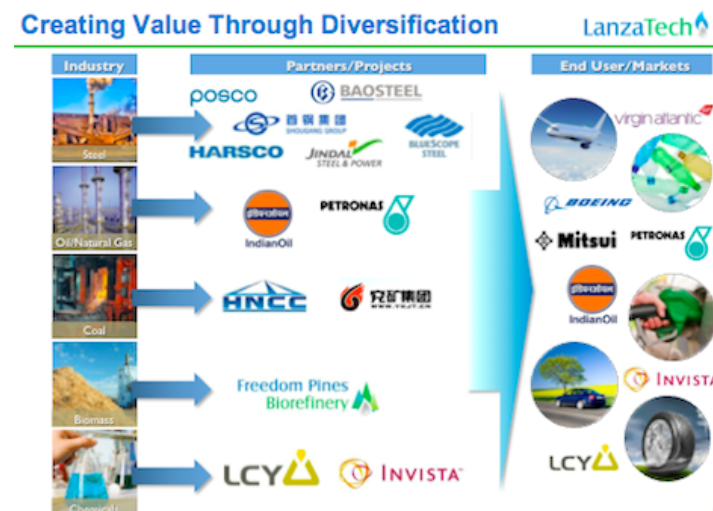
- Biomass to FT fuels
- Feedstock: Forest residues
- TCG Global gasifier
- Veolocys for FT
- Targeting jet fuel
- Partnership with FedEx
- Est. \$180-200 million
- No new news in past 12 months



LanzaTech

Freedom Pines Biorefinery, Soperton, Georgia

- Syngas fermentation to biofuels and other higher-value products
- Process demonstrated on waste gas from steel mills
- 1500 gallons of LanzaTech jet fuel delivered to Virgin Atlantic
- No news in a couple years



Indian River Bioenergy Center

INEOS Bio, Vero Beach, Florida

- No longer gasification related
- New owner, Alliance Energy, focused on fermentation to ethanol




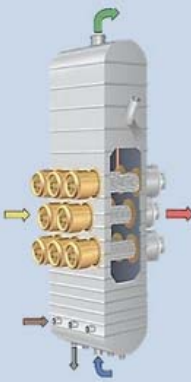
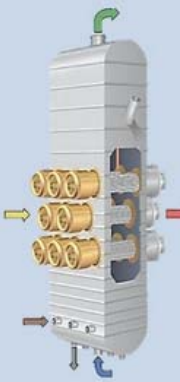
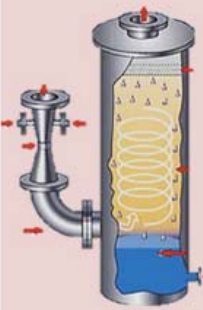




New Planet Energy

- NPE is project developer, not technology developer
- Had been involved in INEOS Bio project
- Stony Point, New York
 - 4500 ton/day MSW
 - 20 million gallons diesel
 - Support from New York
 - TRI gasifier
 - Partnerships secured
 - Currently permitting



New Planet Energy

<p>1 Delivery of Municipal Solid Waste ("MSW")</p> <p>4,200 tons per day of MSW will be delivered by truck to a state-of-the-art recycling center in Stony Point, NY</p> <p>Every ton of waste used by the plant will reduce landfilling, recapture the value of the waste received, and avoid landfill gas emissions that are 20 times more damaging to the atmosphere than carbon dioxide</p> 	<p>2 Waste Processing / Recycling</p> <p>The MSW will be sorted and separated into recyclables (aluminum, metals, paper, plastics, etc.) which will then be bundled and sold, thus recovering resources that would have been lost to landfills</p>  	<p>3 Creation of Solid Recovered Fuel</p> <p>The remaining portions of MSW (food waste, wood, textiles, non-recyclable paper and non-recyclable plastics) will be sorted and sized to create Solid Recovered Fuel ("SRF"), a fossil fuel replacement with a 10,000 BTU energy content per ton</p> 	<p>4 Gasification</p> <p>Next, the SRF will enter a proven, proprietary, clean and efficient steam reformer, which is a completely closed gasification process developed by ThermoChem Recovery International ("TRI"). The SRF will then be transformed into synthesis gas</p> 	<p>5 Gas Clean-up</p> <p>Next, the synthesis gas will go through a gas clean-up process to take out impurities and contaminants, each of which has valuable chemical properties that will be captured and sold as a byproduct of the plant's operations for use in making new products</p> 	<p>6 Fischer-Tropsch & Fuel Upgrading</p> <p>The clean gas will enter a Fischer-Tropsch reactor where it will react with a catalyst and will be converted into clean distillates, which then will go to a fuel upgrading unit to be turned into diesel fuel</p> 	<p>7 Fuel Sales & Distribution</p> <p>The NPE process will produce <u>113,500</u> gallons per day of drop-in sulfur-free renewable #2 cold weather diesel fuel meeting all ASTM specifications.</p> <p><u>This will be the cleanest diesel fuel that exists – cleaner, in fact than any other alternative fuel – with ultra-ultra-low emissions</u></p> 
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