IEA Bioenergy
Technology Collaboration Programme

USA Country Update

IEA – Task 33 Meeting

Robert M. Baldwin
National Renewable Energy Laboratory
Lyon, France
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Updates on Commercialization Activities

- Fulcrum Sierra Biofuels
- Red Rock Bio – cancelled (assets acquired by Next Renewable Fuels)
- Other commercialization activities: two new projects announced
- Comments on the political environment

Fulcrum Bioenergy/Sierra Biofuels

Fulcrum Bioenergy/Sierra Biofuels, Reno NV: (11M GPY nameplate)

1) MRF operational since 2016; at landfill 10 miles from biorefinery
   a) 350,000 tons per year raw MSW => 175,000 tons per year prepared MSW
   b) 120 TPH throughput
2) Gasification/FT
   a) MSW feedstock/TRI indirectly heated fluid bed steam reforming gasifier
   b) Johnson Matthey DAVY™/BP fixed-bed FT (CANS reactor)
3) Phase I is for Fischer-Tropsch wax
   a) Wax to be refined by Marathon
   b) Other offtakers include United and Cathay Pacific, BP Air, World Fuels
   c) FT jet fuel capability to be added in Phase II
4) Plant is 'full scale'; scale up (3X) planned with parallel trains
   a) 12 new projects currently planned/underway
5) Status: First gallon of product in December, 2022; status unclear

Fulcrum BioEnergy/Sierra Biofuels

Plant Construction Activities: May, 2022

New Commercialization Activities

New: SunGas Renewables

- July 26, 2023 – announced the formation of Beaver Lake Renewable Energy, LLC
- New green methanol production facility in Central Louisiana (Pineville LA)
- 400,000 MTA carbon-negative methanol for marine fuel from woody biomass
  - With 1 MTA CCS
- Offtaker: Maersk

New: Aemetis

- Currently producing bio-gas & 1-G ethanol
- September 13, 2023 - received a Use Permit from the City of Riverbank to build a 90 million gallon per year sustainable aviation fuel and renewable diesel plant (from FOGs) in Riverbank, California
  - Will incorporate 'cellulosic hydrogen' from woody biomass
  - Extensive use of CCS
- Details of technology providers not clear at this time

Other Commercialization Activities

DG Fuels

- 12,000 BPD renewable fuels (primarily SAF) project announced
- Gasification/FT – few details provided
- Low CI products with extensive renewable hydrogen (and oxygen) utilization and CO2 abatement (CCS)
- First project announced in Louisiana; application with DOE LPO moving forward

San Joaquin Renewables; San Joaquin, CA

- Gasifier: Frontline BioEnergy RNG
  - Pressurized fluid bed (10 Bar)
  - Air or oxygen with steam (TarFreeGas®; PMFreeGas®)
- Feedstock: Ag wastes
- Product: RNG (15 million gallon-equivalents)
- Status: engineering in progress; approvals for injection in existing pipelines received

Capture the energy ⚡ Release the potential

Other Commercialization Activities

Mote

- Gasifier: SunGas Renewables
  - Pressurized fluid bed (10 Bar) with CCS
- Feedstock: Ag residues
- Product: low-carbon Hydrogen
- Status: initial stages of project planning

Arbor Renewable Gas, Beaumont TX

- Gasifier: SunGas Renewables
  - MTG: Haldor Topsøe
- Feedstock: woody biomass
- Product: 1,000 BPD renewable gasoline (MTG)
- Status: Commercial production in 2024

Madera Gas, Houston TX

- Gasifier: SunGas Renewables (with CCS)
- Feedstock: woody biomass, 100,000 TPY each train
- Product: RNG; 5 production trains => 5B SCFY RNG
- Status: construction on first train in 2023; operational in 2024

Other Commercialization Activities

Velocys, Natchez MS and Immingham UK

- Velocys microchannel FT reactor
- Feedstock: woody biomass (Natchez); MSW (Immingham)
- Product: 35M GPY sustainable aviation fuel (Natchez); 20M GPY (Altalto - Immingham)
- Status
  - Immingham: update by Paula – start-up in 2027; BA fuel offtaker
  - Natchez Bayou Fuels: engineering underway – start-up in 2027; SouthWest Airlines fuel offtaker

USA Bioenergy – Texas Renewable Fuels

- Gasification + Fischer-Tropsch
- Feedstock: woody biomass
- Product: SAF, renewable diesel, naphtha
- Status: Planning underway for first biorefinery in Bon Wier, Texas

The Political Climate

- DOE has issued a roadmap to stand up 4-5 operating biofuels demonstration plants (each at ~1M GPY) by 2030
  - SAF Grand Challenge: 3B GPY SAF is target by 2030; 35B GPY by 2050
  - Gasification + FT is included as a key technology pathway
- BiPartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) both have large investments in biofuels (H2 and SAF)
  - ~ $450B combined; switching from mandates (RFS) to incentives - significant producer tax credits for SAF
  - Hydrogen hubs (4 x $2B each) announced; DAC hubs next
  - Deployment, not R&D
  - Nothing specific called out for biomass but low carbon hydrogen emphasized
- New Funding Agency => Office of Clean Energy Demonstrations
  - DOE/OCED; funding on the order of $3B/yr
  - Mission => steel in the ground

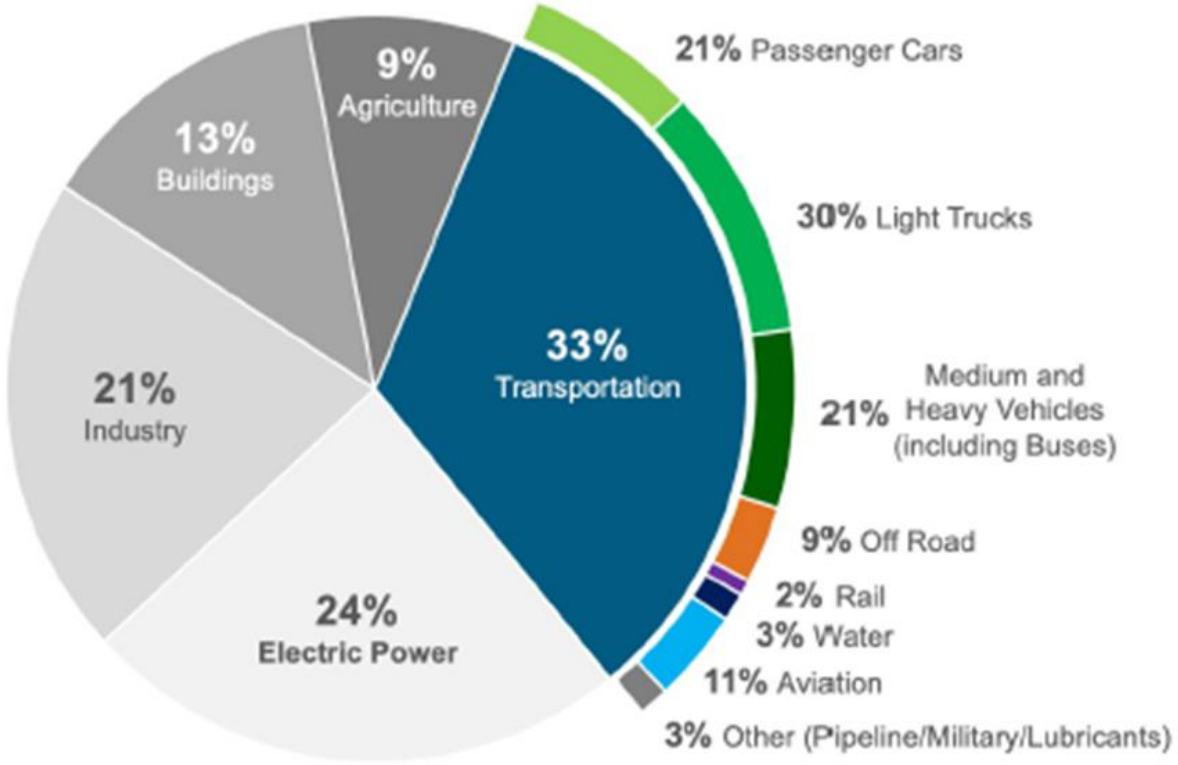
Bioenergy in the USA

Biomass for Bioenergy Consumption, 2022

- 4.8 quadrillion Btu and equal to about 5% of total U.S. primary energy consumption.
  - 2,316 TBtu were from biofuels (mainly 1-G ethanol & biodiesel)

GHG Emissions by Sector

- One-third from transportation
  - Half from light duty vehicles
  - 11% from aviation



IEA Bioenergy

Thanks for your attention!

Robert M. Baldwin
National Renewable Energy Laboratory
Golden, CO 80401 USA
robert.baldwin@nrel.gov

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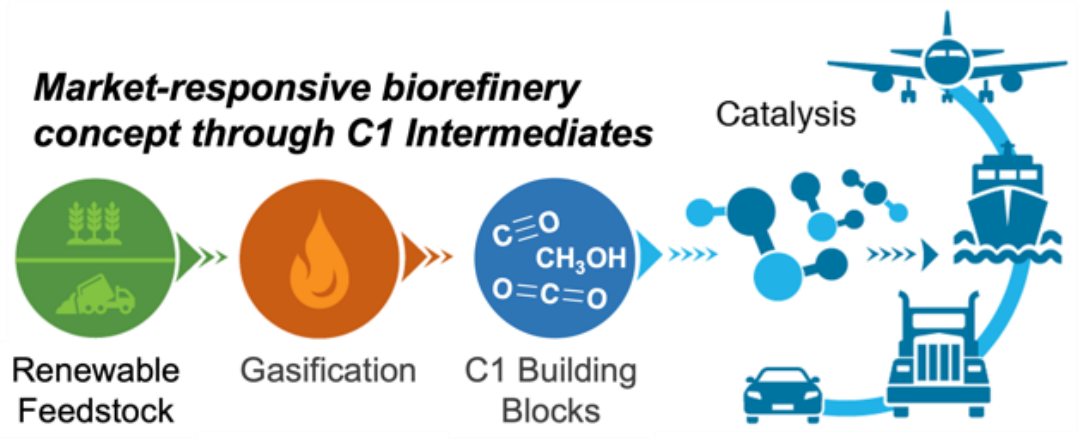
www.ieabioenergy.com

Selected R&D Project

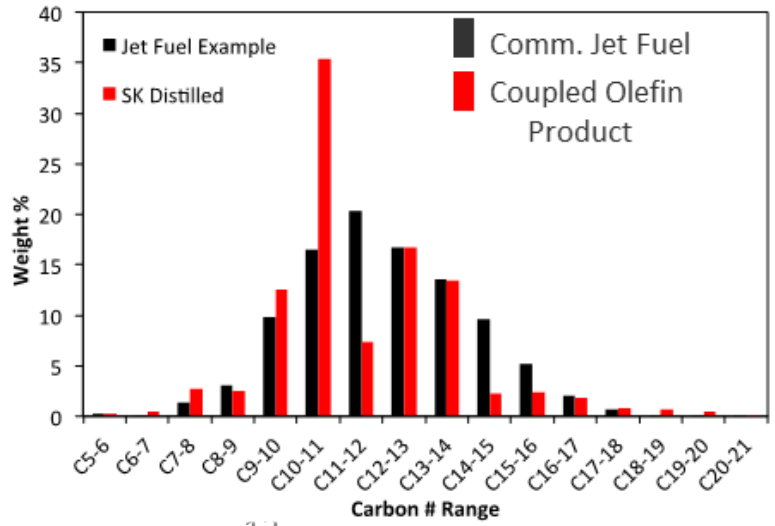
R&D Highlight – NREL
Syngas Upgrading to SAF

NREL developed the centerpiece technology for the **conversion of renewable C1 intermediates** to produce a suite of fuels with **improved carbon efficiency, reduced capital expense, and control of the product distribution to SAF.**



Developed a mild-condition route for coupling syngas-derived olefins to jet-range hydrocarbons

C_4-C_8 Branched **OLEFINS** → C_8-C_{20} Branched **SAF Blend Stock**



Product meets 5 key ASTM International jet fuel property specifications

- ✓ Density
- ✓ Freeze Point
- ✓ Viscosity
- ✓ Heating Value
- ✓ Boiling Curve

Other Commercialization Activities

Lanzatech

- Gasifier: Sekisui (Japan), Ankur (India)
- Feedstock: biomass, MSW
- Product: bio-ethanol and other oxygenates
- Status: developmental work in progress

Aries Clean Energy

- Gasifier: Fluid bed and downdraft gasifiers for syngas production
- Feedstocks: ag waste and bio-solids
- Products: biochar and power
- Status: 3 projects operational (NJ, CA, TN)

Sierra Energy; Ft. Hunter Liggett, CA

- Gasifier: FastOx technology; blast furnace design (~2,200 ºC)
- Feedstock: 20 MTD military waste + woody biomass
- Product: 500 KWhe electricity + 1 BBL/D FT diesel fuel
- Status: operational