Virent Energy Systems Overview

- Founded in 2002
- Based in Madison, WI
- > 70 Employees
- 16 Pilot Plants in Operation
- 29,000 sq. ft. facility
- > $30 MM of Venture Financing

Virent is commercializing proprietary low temperature catalytic processes that convert biomass into hydrocarbon fuels, chemicals, or hydrogen.
Tier-One Global Partners

Government Funded Programs

Over $11 million in Competitive Federal funding
Pathways to Renewable Fuels

- Biomass
  - Pyrolysis
  - Hydrolysis
    - Sugars
      - Fermentation (Ethanol, Butanol)
      - Refining (Gasoline, Diesel)
    - Bio-oils
      - Catalysis (Methanol, Ethanol)
      - Fischer-Tropsch (Diesel, Jet Fuel)
  - Syngas
    - Gasification
      - Fermentation (Ethanol)
  - Aqueous Phase Reforming

BioForming Process to Liquid Fuels

- Carbon Number
- Glycerol
- Sorbitol
- Xylose
- Glucose
- Sucrose
- Polysaccharides
- Cellulose
- Hemi-Cellulose

- CO₂
- H₂
- Natural Gas
- LPG
- Gasoline
- Jet Fuel
- Diesel
Virent Attributes

Life Cycle

Feed: Water Soluble Sugars
Product: Gasoline, Jet Fuel, Diesel
Process: Solid State Catalyst

Economics

Virent Feed Stock

Feedstock Flexible.
- Conventional and Non-Food Feedstocks
- Sources: Sugar Cane Bagasse, Sugar Beet Pulp, Wheat Straw, Woody Biomass, Switchgrass
- Allows processing of mixed sugar streams including water soluble polysaccharides and non-food hemi-cellulosic sugars
Virent Process

- Inorganic Catalysts not Living Organisms.
- Low temperature process.
- Liquid fuel products separate naturally from aqueous feedstocks; no distillation needed.
- Product slate is tunable.
- Achieved high yields of biogasoline from C-5’s, C-6’s, corn syrup and sucrose feedstocks.

Virent Products

- Conventional Hydrocarbons- Gasoline, Jet Fuel, Diesel
- Product can be blended or used as a drop-in replacement.
- 50% higher energy density than ethanol.
- Will avoid massive fueling & engine infrastructure investment.
- Process can be tuned to alter yields to hydrogen, light hydrocarbons, heavier hydrocarbons, and alcohols.
Cane Sugar and Xylose to Bio-Gasoline

Bio-Gasoline Composition
Same Components as Unleaded Gasoline

- Unleaded Gasoline
  - 115,000 BTUs/Gal

- Bioforming Green Gasoline
  - 115,000 BTUs/Gal

- Ethanol
  - 76,000 BTUs/Gal
Virent Life Cycle

- Energy Balance: Produces gasoline with >50% higher net energy yield per acre than the corn ethanol process.
- Water Positive: The BioForming reaction is a net producer of water.
- CO2 Neutral: Low energy input and biomass based feedstocks offer near-zero CO2 process emissions.
- Low Energy Separation: Liquid hydrocarbons naturally separate from water.

Virent Economics

Feed: Water Soluble Sugars
Product: Gasoline, Diesel, Jet Fuel
Process: Solid State Catalyst
Conclusions

- Virent’s BioForming Process
  - Produces Conventional Liquid Fuels Economically and Efficiently
  - Based on Heterogeneous Catalysis
  - Feedstock Flexible
  - Tunable to Alter Product Yields
- Virent and Shell are collaborating to commercialize the BioForming process for gasoline production.
- Biorefineries incorporating next generation biofuel technologies will produce higher quality fuel products and a broader range of renewable chemicals and materials.