Speakers

John S. Russin
Vice Chancellor, LSU Agricultural Center
*Feedstock*

Brice Dally
R&D Manager, Virent
*Conversion Technology*

Cynthia Ginestra
Aviation Fuels Research Engineer, Shell Global Solutions
*Jet Fuel*
A Regional Program for Production of Multiple Agricultural Feedstocks and Processing to Biofuels and Biobased Chemicals

John S. Russin
Vice Chancellor
LSU Agricultural Center
USDA AFRI
Regional Bioenergy Projects
11 Louisiana Sugar Mills Operate 3 – 4 Months
> 650K Tons Bagasse Annually
Designated Feedstocks

Energycane
September – March

Sweet Sorghum
July – October

Existing: bagasse, syrup, molasses
Designated Feedstocks

Project Goals
- Diverse feedstock streams of biomass, sugar syrup
- Year-round supply
Many Partners

- eSUBI
- VIRENT
- JOHN DEERE
- GENENCOR®
- ONVIROSCAPES
- Optinol
- Ceres
- Sugar Cane Growers Cooperative Of Florida
Many Partners

> 60 different scientists and support staff
Energycane

Sugarcane – a hybrid, ~ perennial

High fiber, low sugar

USDA ARS Houma, LSU AgCenter

Low inputs, longevity

New varieties, markers, cold tolerance
Energycane Yield Potential

Potential Yield
(dry tons per acre harvested)
Energycane Yield Potential
Sweet Sorghum

Annual
- Juice – syrup
- Seeds – starch
- Stalks – biomass

Maturity 90 – 150 days

Much of eastern U.S.

Ceres, LSU AgCenter
Sweet Sorghum Inputs
Sweet Sorghum Inputs

Cover crops provide necessary nitrogen
Planting cost ≈ $24 - 30/acre
Replacement nitrogen cost ≈ $40 - 60/acre
Sweet Sorghum Inputs

Cover crops provide necessary nitrogen
Planting cost ≈ $24 - 30/acre
Replacement nitrogen cost ≈ $40 - 60/acre

Insecticides
Herbicides
Sweet Sorghum Yield Potential

Potential Yield (dry tons per acre harvested)
## Crop Comparison

<table>
<thead>
<tr>
<th></th>
<th>Energycane</th>
<th>Sweet Sorghum</th>
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</thead>
<tbody>
<tr>
<td>Harvest duration</td>
<td>7 months</td>
<td>3 – 4 months</td>
</tr>
<tr>
<td>Inputs</td>
<td>None *</td>
<td>$150 – 200/acre *</td>
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<tr>
<td>Planting</td>
<td>Perennial</td>
<td>Annual</td>
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<tr>
<td>Marginal lands</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Dry ton/acre</td>
<td>5-15 (20)</td>
<td>5-10 (15)</td>
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* Excluding costs for crop establishment.
<table>
<thead>
<tr>
<th>Month</th>
<th>Energycane</th>
<th>Sweet Sorghum</th>
<th>Bagasse</th>
<th>Syrups</th>
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<tbody>
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<td>Jan</td>
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<td>Dec</td>
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</table>
Marginal Lands

2.45 million acres of idle cropland
Optimal Plant Locations
Biomass Crop Logistics

Harvest/transport equipment
- Inside cane belt
- Outside cane belt
Biomass Crop Logistics

Low-input crops
• Minimal pesticides
• Dense canopies
• Minimal fertilizer

Complete production guides available for both crops
Environmental Impacts: Soil Carbon

Converting fields to biomass crops
- Increased soil labile C
- Early indication of improved soil C sequestration
Targeted Bioproducts

- Syrups
  - From biomass
  - From juices

- Nanomaterials & Biopolymers
  - Electrical storage
  - Bioplastics
  - Biomedical materials

- Biobutanol
  - Fermentation
  - Separation

- Specialty products
  - Adhesives, epoxies, chemicals
Possible Future Work

Feedstock effects on processes
- Crop species – syrup quality, purity
- Syrup source – juices, cellulose deconstruction
- Support for standardized evaluation – ex. NCERC

Feedstock system effects on air quality
- Species and sources
- Process and formulation differences
- Support for local/regional air quality evaluation
Brice Dally
Virent R&D Manager
CAAFI SOAP-Jet
January 22\textsuperscript{nd}, 2016
Virent Overview

*Leading catalytic route to renewable hydrocarbon fuels and chemicals.*

- Founded in 2002 and headquartered in Madison, Wisconsin, USA
- Industry leaders as partners and investor
  - Royal Dutch Shell, The Coca Cola Company, Cargill, Honda
- **BioForming® Technology**: Continuous process, catalytic technology, scalable
- Facilities include pilot and demo plants, catalyst development lab
- **Extensive Intellectual Property (IP) portfolio**
  - 120+ patents issued, 140+ patent pending applications

**Partners & Investors**

**Operations and Infrastructure**
Virent BioForming® Technology

*Leading catalytic route to renewable hydrocarbon fuels and chemicals.*

- **Fast and Robust**
  - Inorganic Catalysts
  - Moderate Conditions
  - Industry Proven Scalability

- **Energy Efficient**
  - Exothermic
  - Low Energy Separation
  - Low Carbon Footprint

- **Premium Drop-in Products**
  - Tunable Platform
  - Infrastructure Compatible
  - Fuels and Chemicals

- **Feedstock Flexible**
  - Conventional Sugars
  - Non-Food Sugars

“Eagle” Virent’s Biogasoline Demonstration Plant- Madison, WI
Sustainable Bioproducts Initiative

LSU LED PROJECT - A REGIONAL PROGRAM FOR PRODUCTION OF MULTIPLE AGRICULTURAL FEEDSTOCKS AND PROCESSING TO BIOFUELS AND BIOBASED CHEMICALS

USDA NIFA AFRI Bioenergy CAP: Award No. 2011-69005-30515
Timeline: 5 year project starting Q3 2011

Virent and team members will demonstrate agronomic, economic, technical, and sustainability attributes for energy cane and sweet sorghum to biofuels and bioproducts in the Southeast U.S.
Virent Conversion Platform

- Ethanol Conditioning (Virent or 3rd party)
- Aromatics Complex
- Virent BioFormate Aromatics Production
- Virent Distillate Production
- Virent Sugars Conditioning

- Conventional Sugars (Corn Starch, Cane Sugar, Beet Sugar)
- BIOMASS Third Party Deconstruction
- BIOMASS Deconstruction

- Ethanol
- Virent Technology
- Industrial Solutions

- Tier 1 Feedstock
- Tier 2 Feedstock
- Virent Technology
- Industrial Solutions

- SAK = Synthetic Aromatic Kerosene
- SK = Synthetic Kerosene

- p-Xylene
- Benzene
- Toluene
- Gasoline
- Jet Aromatics (SAK)
- Light Cycle Oil
- Gasoline
- Jet Fuel (SK)
- Diesel

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Virent Conversion Platform

- Virent LSU SUBI Project focus: new sugar feedstocks to aromatic blendstock for chemicals and fuels

Ethanol Conditioning (Virent or 3rd party)

Virent BioFormate Aromatics Production

Aromatics Complex

- p-Xylene
- Benzene
- Toluene

Fuels

Jet Aromatics (SAK)

Light Cycle Oil

Fuels

Jet Fuel (SK)

Diesel

Gasoline

Tier 1 Feedstock

Tier 2 Feedstock

Virent Technology

Industrial Solutions

SAK = Synthetic Aromatic Kerosene  SK = Synthetic Kerosene
Virent Competitive Advantages

Low cost bio-based route to aromatics

Potential to access more of biomass carbon than fermentation processes

Ash content important for catalysis to avoid poisoning

Higher yields than biological pathways
Biomass Hydrolysate/Sugar Quality

*LSU Energy Cane – Attractive Contaminant Profile for Catalysis*

**Various Suppliers**

- **Corn Stover**
- **Woody Biomass**
- **Sugar Beet**
- **Sugar Cane**
- **Corn Syrup**
- **Energy Cane**

**Contaminant Concentration**

- Organic Acids
- Anions
- Metals

**Biomass Hydrolysates**

**Sugars**

- Raw
- Refined

**Various DE**
Baseline results generated within SUBI consistent with runs of hundreds of days in other projects
2 gallons of LSU Energy Cane processed continuously for 6 days until feedstock was depleted
LSU Sweet Sorghum run to be completed Q1 2016
Joint Techno-Economic Analysis with LSU and Virent based on data
Virent BioFormPX® Paraxylene Used for World’s 1st PET Plastic Bottle Made Entirely From Plant-Based Material

Virent, Coca-Cola hit key production milestone with the 100% biobased Plant Bottle

The Iconic Coca-Cola Bottle is Getting a Surprising Update

Coke, Virent debut plastic bottle made 100% from plant materials

PlantBottle 2.0: Coca-Cola Unveils World’s First PET Plastic Bottle Made Entirely from Plants

New Coke bottle made entirely from plants

Coca-Cola’s first 100% biosourced PlantBottle debuts at Expo Milan
Product and Field Platforms

Aromatic Chemicals
- APR Process
- BioForming Process
- Aromatics Upgrading
- Sugars to Sugar Alcohols

Benzene
Toluene
Xylenes

Aromatic Fuels
- APR Process
- BioForming Process
- Sugars to Sugar Alcohols
- Gasoline Compositions

Gasoline
AvGas
Jet – SAK
Light Oils

Distillate Fuels & Oils
- APR Process
- BioForming Process
- Jet Fuel Composition
- DHOG Process

Jet – SK
Diesel Fuel
Heavy Oils

Mixed Oxygenates
- APR Process
- Sugars to Sugar Alcohols

Solvents
Glycols
Alcohols

Specialty Products
- APR Process
- BioForming Process
- Sugars to Sugar Alcohols
- Others

Lactic Acid
Sorbitol
Xylitol
Mineral Oils

Sugar Cane
Corn
Sweet Sorghum
Energy Cane
Biomass
Biomass

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Virent/Shell Partnership

• Joint Development of Technology Platform
• Joint Collaboration on Product Qualification
• SK and SAK Jet Fuel
Thank You

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