Energy Cane for Bioenergy and Nutraceuticals

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Outline

- Company Background
- Importance of Feedstock
- Energy Cane Development and Agricultural Activities
- Applications and Key Attributes
- Processing options
- Conclusions
Canergy is a Biotechnology company focused on agronomy and development of Energy Cane, a sustainable non-food energy crop, for biofuels, bioenergy, and biochemicals

Core strength in biomass feedstock development and applications

Sweetstreams BIOTECH is a health products company focused on production of nutraceuticals, prebiotics and antioxidants from Energy Cane

Core strengths in bioprocess technology and health

Capitalizing on distinct attributes of energy cane (“high fiber” cane varieties for different products and applications
Key Development Accomplishments

- **CANERGY**: 5+ years of Energy Cane and project/site development
  - Field trials and evaluation of 23 varieties, over 250 acres
  - Pilot scale trials to validate performance
  - Process design and development

- **SWEETSTREAMS**: 1.5+ years of process and product development
  - Proprietary, patent pending extraction and purification process
  - Product and market development of prebiotics and antioxidants
The Importance of Feedstock

- Major cost driver - often >80% of operating costs for bioenergy processes
  - Lux Research estimated delivered cost at
    - $80 to $100/ODMT for ag residues
    - $50/ODMT for woody biomass residues

- Land Use, Logistics and Storage
  - Harvesting 1-2 tons/ac means up to 320,000 acres of land to supply a 25 MMGPY ethanol plant
  - $25/ODMT for transport and storage of corn stover and wheat straw
Energy Cane Attributes

- C4 plant generally more vigorous than commercial sugarcane varieties grown for sugar, and sweet sorghum
- Largely derived from clones of Saccharum spontaneum
  - “Sugarcane” modified to obtain higher fiber than sugar
  - Can select sugar content, fiber content, lignin content, and extractives in Energy Cane varieties to satisfy project needs
- Can be grown on a wide range of soil textures and marginal lands, and is more water tolerant
- Can be grown anywhere sugarcane is grown
- 5 to 7 ratoons likely
Agronomy of Energy Cane
California Imperial Valley Advantages

► Sunlight
  ► Averages 8h/d of sunlight in winter - most of any location in the U.S.
  ► 360 days of sunshine every year

► Water
  ► Desert: Avg 2.9 inches rain/y
  ► Controlled water supply by irrigation
    ► Preferential Colorado River water rights

► Temperature
  ► Mild winters, plus hot summers

► Harvest 10 - 11 months per year
Activities with Energy Cane

- Feedstock and technology development program
- **High yield, high fiber varieties** suitable for ethanol from sucrose and lignocellulosic fractions
  - First lignocellulosic ethanol plant to be based upon a dedicated energy feedstock
- **High Lignin varieties** suitable for pellets and Biopower
- **Biomass-derived extracts** for nutraceuticals, prebiotics, and cosmetics
Feedstock Evaluation, Performance Criteria

- 23 varieties planted in the Imperial Valley of California
  - Plantlets, whole stalk planting
  - Five different fields, about 250 acres (115 Ha)
  - Irrigated - conventional and drip

- Evaluate growth properties and attributes
  - Yield, stalk weight, %T&L
  - Content of soluble and insoluble CHOs and lignin
  - Fiber composition - cellulose, hemicellulose, lignin, ash

- Conversion of key carbohydrates - sucrose + lignocellulosics

- Sugar / lignin / fiber / product yield per acre
  - Drives cost/value of feedstock
Energy Cane Grows Quickly!

- Production…………….80 to 120 green tons/acre
- Water requirements…Same as (or less than) other crops
- About 80 – 100 stalks per plant
- Up to 2 pounds (wet) per stalk at harvest
- 50 – 70 pounds (dry) harvested per plant
- Additional 25 – 35% in underground root mass
Varieties Extensively Studied to Date

<table>
<thead>
<tr>
<th>Carmine</th>
<th>Josiah</th>
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<tbody>
<tr>
<td>Colby</td>
<td>Macy</td>
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<tr>
<td>Jackson</td>
<td>Mariella</td>
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<tr>
<td>Jamie</td>
<td>Nali</td>
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<td>Japheth</td>
<td>Samuel</td>
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Key Differences Between Varieties

- Wide variation in field properties between varieties
  - stalk weights, yields
- Wide variation in Brix between varieties
  - Brix increases as crop matures
- Smaller variation in moisture content and composition of lignocellulosic fraction
- Some varieties with more waxy surface suitable as source for high value extractives
Yields for Energy Cane Varieties
8 months growth

Green tons per acre

Japheth  Nali  Samuel  Jamie  Josiah  Macy  Jackson  Carmine

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Financial Implications: Feedstock

- High yields (25 - 40 ODMT/ac; 50-85 ODMT/Ha) dramatically reduce land requirements and transport costs
- Ability to harvest directly from field eliminates storage costs, improves product quality and reduces cost/infrastructure for on-site storage
  - Aggregate savings of $25-$35/ODMT
- Ten-year fixed cost agreements with growers (also shareholders) means feedstock costs are controlled, and well below the “all-in” cost for corn stover and wheat straw
Energy Cane Cost Analysis

• Cost are based on Canergy’s analysis of:
  • Sucrose derived ethanol
  • Industry standard cellulose and hemicellulose conversion per dry ton
• Costs below include grower contracts with harvest hauling (field to processing)
• Does not include BCAP opportunities & CEC Grant opportunities

<table>
<thead>
<tr>
<th>Yield: green tons / acre</th>
<th>70</th>
<th>75</th>
<th>80</th>
<th>85</th>
<th>90</th>
<th>95</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ per gallon</td>
<td>$0.93</td>
<td>$0.87</td>
<td>$0.81</td>
<td>$0.77</td>
<td>$0.73</td>
<td>$0.69</td>
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<tr>
<td>$ per d/t feedstock</td>
<td>$63</td>
<td>$59</td>
<td>$55</td>
<td>$52</td>
<td>$49</td>
<td>$47</td>
</tr>
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</table>
What About Other Opportunities?

Consider Individual Components and Their Value
Composition of Green Energy Cane Varieties

Wt%, Wet Basis

- Sucrose
- Glucose
- Fructose
- Cellulose
- Xylan
- Lignin
- Other

Colby vs. Jamie + Jackson
Performance Implications:
Potential Ethanol per Green Ton

USG per Green Ton

Colby

Jamie + Jackson
Look for Value
Composition on a dry basis

- Glucan + Hemicellulose: 50%
- Lignin: 17%
- Sucrose: 13%
- Protein: 8%
- Ash, Acetate, Other Solids: 4%
- High Value extractives: 8%
Higher Value Products

- Extract high value products for nutraceutical and cosmetics applications
  - Targeted oligosaccharides as prebiotics
  - Antioxidants
  - Anti-inflammatory compounds
- Capitalize on specific attributes of each energy cane variety
  - Higher wax and extractive content
  - High lignin: power or pellets
  - High fiber: biomass-derived sugars and fuels
- Share infrastructure costs and reduce OpEx

\[ \begin{align*}
\text{\$75,000 per acre} \\
\text{\$3,500 per acre}
\end{align*} \]
Processing Option: Nutraceuticals, Sugars and Pellets/Power

Cane Feedstock → Milling → Extraction Process → Pellets or Power generation

Milling → Sugars, Extractives

Sugars, Extractives → Recovery and Purification → High Value Nutraceuticals

Organic Cane Juice
Conclusions

- Energy Cane in the CA IV is a phenomenal feedstock
  - 70 to 120+ green tons per acre
- Tailored use for biofuels, sugars and biochemicals, and high value nutraceuticals
  - 8 - 16% extractable as high value prebiotics, proteins and nutraceuticals
  - 6 - 8% sucrose content
  - 60 - 70% glucan + xylan (dry) in bagasse, tops and leaves
- Several options for co-processing - reduces capital and operating costs
  - Strategic partnership and development opportunities
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