Project Summary Presentation

Conversion of Biomass into Electrical Energy and Compost through Sequential Batch Anaerobic Composting

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Project Partners

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Project Focus

To convert biomass into electrical energy and compost with a highly improved anaerobic digestion technology.

– Feedstock: renewable biomass of sugarbeet tailings and other byproducts generated in the refining process at the American Crystal Sugar Company

– Technology: University of Florida anaerobic digestion technology (SEBAC II) originally developed for space applications
Project Goals

• To convert a renewable biomass of sugarbeet tailings and other sugar refining byproducts into usable electrical energy and compost by utilizing the SEBAC II technology.

• Conduct laboratory analysis on the quality and quantity of methane generated with expected conversion rates to electrical energy

• Design and construct a demonstration facility for processing 10 – 100 tons of tailings per
Project Goals

• Perform a study on the demonstration facility to determine the economic feasibility of bringing the system to full-scale commercial use at the American Crystal Sugar Company East Grand Forks Facility

• Develop a list of target companies in or near the Xcel Energy service area that are potential users of a SEBAC II system and introduce them to the technology. Offer an opportunity to visit the American Crystal Sugar Company facility to see a real-time demonstration.
Sugarbeet Tailings
From
American Crystal Sugar Company
Project Approach

• Laboratory scale analysis to determine:
  – biochemical methane potential of tailings and other byproducts
  – extent of degradation of these feedstocks
  – amount of residue remaining after anaerobic digestion

• Test the applicability of SEBAC II process to biogasify sugarbeet tailings in a laboratory scale system.

• Improve or modify process if required and validate it at the laboratory scale.

• Develop a process design for the demonstration facility.

• Construct, start up and operate the demonstration facility.
Project Results

• Project Goals have all been met
• Production Results
  – Tailings degraded very rapidly
  – 10 tons/week processed
  – Biogas yield was 2400 cu ft/ton wet weight of which 55% was methane
  – Energy equivalence of 1.32 MMBtu/ton wet weight
  – 80-90% of the dry weight of tailings was degraded
Project Results

• Technology Enhancements
  – New system design that is a Hybrid Two Stage entitled “System for Semi-Continuously Fed Anaerobic Digestion of Solid and Soluble Organic Wastes by Products and Residues”
  – System kinetics increased
    • Maximum biogas produced in shorter timeframe
    • Feedstock broken down in shorter timeframe (< 10 days)
  – Demonstration system can process 50% more than the design capacity
  – Compost/residue is free of plant pathogens and active weed seeds (collaboration with the University of Minnesota)
  – Commercial system will only require 2 tanks versus 20
Project Results

• Economic Analysis for Full-Scale System at East Grand Forks
  – Biogas to power generation
  – 390 tons/day of tailings
  – Power potential: 2.1 MW (50,000 kWh/day)
  – Capital cost estimate: $4.9 M
  – Simple payback: 5.8 years
  – Power produced at 1.2 /kWh
Project Results

• Commercialization Potential
  – System can be scaled, ie. 10 tons per week to 400 tons per day
  – System footprint is small, even for large endeavors
  – System can handle multiple feedstocks at one time
  – Biogas can be used directly in boilers, cleaned for pipeline use, or converted to electrical energy
    • At full-scale estimate a 2MW system
  – System can be applied to a variety of industries producing biomass waste and/or by-products
Benefits to XCEL

• Viable renewable technology to convert biomass to electrical energy
• Technology can support a variety of feedstocks at the same time
• Technology is scalable and can support users at all levels
• Return on investment between 2 – 5 years, depending on system size
• Increased supply of electricity available to customer base
• Rural area economic development
  – Industry growth
Commercial Interest

• Many end-users interested in implementing technology
• Four entities have expressed interested in further discussions to potentially acquire the technology through a license agreement and/or partnership agreement
  – Equipment/System Manufacturers
  – Engineering Consulting Firms
  – Venture Capital
Technology Promotion

- **News Media**
  - Minnesota Public Radio (May 6, 2008)
  - Grand Forks Herald (June 8, 2008)
  - Biomass Magazine (August 2008)

- **High Solids Anaerobic Digestion Workshop**
  - Held in Fargo on December 11, 2008
  - 75 people in attendance
  - Technical sessions and tour of demonstration facility
Technology Promotion (cont)

• Students Participating on Project
  – 2 Ph.D.
  – 2 Master
  – 1 Undergraduate

• Conference Presentations/Papers
  – 5 Presentations at International Conferences

• Educational Seminars
  – Minnesota State Community & Technical College
  – Bemidji State University
Technology Promotion

• University Symposia
  – 4 Symposia given at the University of Florida

• Peer-Reviewed Papers and International Journals
  – 4 Published
  – 5 Pending

• One-on-one meetings with various groups
  – Industrial (16) - City (4) - County (4)
  - Federal (4) - University (4)
## Additional Funded Contract Work

<table>
<thead>
<tr>
<th>Entity</th>
<th>Description</th>
<th>Funding</th>
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<tbody>
<tr>
<td>American Crystal Sugar Company</td>
<td>Provide laboratory analysis on pressed sugarbeet pulp and CSB rafinate to determine biochemical methane potential and degradation time</td>
<td>$21,468</td>
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<tr>
<td>NASA – Johnson Space Center</td>
<td>Phase I: Provide laboratory analysis and preliminary designs for two systems, the first being an on-site system for Center municipal waste, and the second for a lunar base waste application</td>
<td>$225,000</td>
</tr>
<tr>
<td>American Crystal Sugar Company</td>
<td>Charge and operate the demonstration system with a new feedstock of pressed pulp and tailings combined, and analyze the results</td>
<td>$24,605</td>
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<tr>
<td>Nordic Sugar</td>
<td>Provide laboratory analysis on whole sugarbeets to determine biochemical methane potential and degradation time from anaerobic digestion</td>
<td>$27,588</td>
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# Pending Projects

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Ottertail Ag Enterprises</td>
<td>Provide laboratory analysis on thin stillage to determine biochemical methane potential and degradation time from anaerobic digestion</td>
<td>$36,488</td>
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<tr>
<td>Ottertail Ag Enterprises</td>
<td>Analyze the thin stillage and anaerobic digestion effluent to determine if the fluids can be remediated for reuse applications within the facility, and determine the appropriate technology</td>
<td>$92,500</td>
</tr>
<tr>
<td>Hennepin County</td>
<td>Provide laboratory analysis on municipal biomass feedstocks and an economic analysis for anaerobic digestion operations for different sized systems</td>
<td>TBD</td>
</tr>
<tr>
<td>American Crystal Sugar Company/Nordic Sugar Company/Ottertail Enterprises</td>
<td>Charge and operate the demonstration system with whole sugar beets and obtain analytical results.</td>
<td>TBD</td>
</tr>
<tr>
<td>American Crystal Sugar Company/Ottertail Enterprises</td>
<td>Charge and operate the demonstration system with thin stillage as the feedstock and analyze the results.</td>
<td>TBD</td>
</tr>
<tr>
<td>NASA Enterprises on Space Center</td>
<td>Phase II: Provide final designs and construction estimates for both an on-site system and a lunar-based system.</td>
<td>TBD</td>
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## Potential Opportunities/Collaborations

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<tr>
<td>University of Minnesota – Crookston</td>
<td>To customize and build an anaerobic digestion system for on-campus use to handle biomass waste products from municipal and agricultural sources, and to use the biogas for infrastructure support.</td>
</tr>
<tr>
<td>Hennepin County/Linden Hills Power and Light</td>
<td>To develop and build an anaerobic digestion system for neighborhood biomass waste and to use the biogas directly or convert it to electrical energy to support local area needs.</td>
</tr>
<tr>
<td>Hennepin/Ramsey/Washington Counties</td>
<td>To develop an anaerobic digestion demonstration system at one of the Minneapolis/St. Paul metro area composting sites to compliment the biomass collection and use program already in place and to generate energy.</td>
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<tr>
<td>Ryan Potato</td>
<td>To develop and build a full scale commercial system to handle potato culls from their facility operations. Two proposals already submitted.</td>
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<tr>
<td>American Crystal Sugar Company</td>
<td>To develop and build a 60 – 100 ton per day anaerobic digestion system based on and scaled up from the 10 ton per week demonstration system currently housed at their Moorhead facility.</td>
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Questions?
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