The Key To A Sustainable Gen2 Industry

Pretreatment

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The Key To A Sustainable Gen2 Industry

- To be price competitive, sugars – the building block for cellulosic ethanol and other bio-based chemicals - must be produced at large scale in a technically and cost-efficient way

- Pretreatment is the 1st and critical process step - and -is the key to doing so

- We have developed superior pretreatment equipment and continuous process technology using a highly modified twin-screw extruder (‘TSE’) to recover the highest percentage of separate, clean streams of C5 and C6 sugars from a wide range of biomass feedstocks

- Our proprietary pretreatment technology is a cost effective solution

- This year - building and operating a demonstration ‘skid-mounted’ mobile system that will enable final design spec’s and mitigate scale-up risks for commercial scale

- Plan to begin commercialization in 2015
About GreenField

- Founded in the early 1990’s – GreenField has grown to become Canada’s largest producer of fuel ethanol and industrial/beverage/pharmaceutical specialty alcohols

- We own and operate 4 dry mill corn ethanol plants in Eastern Canada as well as 3 downstream high purity industrial packaging facilities in Canada and the U.S.

- 2013 Statistics:
  - Annual sales in the range of $800 million
  - Employ 420 staff
  - Produce a combined 655 MLPY of alcohol and ethanol
  - 530 MLPY was fuel ethanol (30% of total Canadian Production)
GreenField’s Corn Ethanol Plants & Downstream Packaging Plants

Gen1 Corn Ethanol Plants

- Varennes, QC
- Chatham, ON
- Tiverton, ON
- Johnstown, ON

Downstream Packaging Plants

- Brampton, ON
- Brookfield, CT
- Shelbyville, KY

Driven by nature
Our R&D Facilities Support Innovation

For GreenField – *Innovation is the Key to Prosperity*

- We have an in-house expertise to design and execute major capital and R&D projects
  - at any time 20-30 innovation projects are in the queue

- We established extensive R&D facilities at our Center of Excellence in Chatham - a **Continuous Pilot Plant**, an **Indoor Pilot**, and a fully equipped **Supporting Lab**
  - staffed with a full-time Team of 15 scientists, engineers, project managers, lab technicians and operators

- They support our innovation projects:
  - **On Gen 1** - to increase revenues by creating new value-added products - and to reduce costs through improved yields and process efficiencies, and
  - **On Gen 2** - to develop new technologies that can process lignocellulosic feedstocks
Pretreatment Challenge & Solution

- **Maximum sugar recovery**
  - Average maximum theoretical yield from C6 & C5 sugars sources is **430 L/MT**
  - Best-in-class targeted yield capability is in the range of **315-330 L/MT** (74-77%)

- **Solution is to develop a PRETREATMENT PROCESS** that:
  - generates highest recovery from available C6 and C5 sugars sourced from the widest variety of biomass feedstocks
  - in their ‘cleanest’ form for optimal downstream hydrolysis and fermentation – enabling highest cellulosic ethanol yield
  - and to also develop the **EQUIPMENT SYSTEM** to execute that process in a technically and cost efficient way

- **Our first step was to develop the process**

- **Pioneered 2-stage pretreatment for versatility** – can efficiently process high lignin as well as low lignin feedstock
Some Key ‘Facts’ Regarding Our Yield Results*

- We validated our process at batch, and then continuous Pilot scale using 3 metrics – (1) Sugar Recovery, (2) Hydrolysis, and (3) Fermentation

<table>
<thead>
<tr>
<th>Process</th>
<th>Efficiency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretreatment</td>
<td>89%</td>
<td>Of overall incoming C5 + C6 sugars are recovered after pretreatment</td>
</tr>
<tr>
<td>Hydrolysis</td>
<td>87%</td>
<td>Of recovered C5-C6 sugars are hydrolysed into fermentable monomers</td>
</tr>
<tr>
<td>Fermentation</td>
<td>92%</td>
<td>Of C5 + C6 monomers are converted to ethanol</td>
</tr>
</tbody>
</table>

- Our benchmark ethanol yield is 330 L/MT (no acid catalyst, e.g. corn fibers)
- Focused on woody biomass – on poplar, is 338 L/MT using all sugars and ~ 76 L/MT to ~ 78L/MT poplar from the C5 sugars only

* Validated by 3rd party collaborators
GreenField’s Pretreatment Equipment Solution

• To make that process a commercial reality:
  - We needed an EQUIPMENT SYSTEM that was technically efficient and versatile but not complex or expensive

• Our answer
  - We developed, in-house, a unique filtering system incorporated into a twin-screw-extruder

• Performs multiple functions in one piece of equipment
  - Cleans and separates the 2 sugar streams
  - Contributes to the cook and activation of the cellulose

• Is CAPEX and OPEX efficient
<table>
<thead>
<tr>
<th>Key Operating Parameters for Interstage Washing - Solid/Liquid Separation</th>
<th>Our Modified TSE</th>
<th>Other Commercial Off-the-Shelf Equipment Adapted from P&amp;P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piece(s) of Equipment required to process 10% DM Feed</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>• Modified TSE</td>
<td>• Drainer screw</td>
<td></td>
</tr>
<tr>
<td>• Single screw press</td>
<td>• Modular screw device</td>
<td></td>
</tr>
<tr>
<td>Screw (#)</td>
<td>1 x 2</td>
<td>3 x 1</td>
</tr>
<tr>
<td>Shearing</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Pressure (psig)</td>
<td>2,000</td>
<td>300</td>
</tr>
<tr>
<td>Pore size (sq in)</td>
<td>1/8,000th</td>
<td>1/80th</td>
</tr>
<tr>
<td>Porosity (%)</td>
<td>≥25%</td>
<td>≤25%</td>
</tr>
<tr>
<td>Discharge (% DM)</td>
<td>60%-70%</td>
<td>45%-50%</td>
</tr>
<tr>
<td>Suspended solids (% DM) in discharge</td>
<td>&lt;1%</td>
<td>3%</td>
</tr>
</tbody>
</table>

- Pulp and Paper / Oil Seed Processing industry can be the beneficiaries of these KPI’s – e.g. using a clean C5 sugar / oil stream to manufacture cellulosic ethanol / biodiesel or other biobased chemicals (polymers, resins)
GreenField’s Pretreatment System Technology

GREENFIELD’S BIOMASS-AGNOSTIC “GEN 2” PRETREATMENT SOLUTION
GreenField’s Pretreatment System Technology
Aggressive Intellectual Property Protection Strategy

Global Patent Portfolio

- GreenField has filed 18 patent application ‘families’ in connection with its proprietary PROCESS + EQUIPMENT technology, totalling 142 patent apps filed in +50 countries

- Protected ‘PROCESS’ IP via a suite of 14 patents/apps:
  - 3 granted in U.S. + 6 granted in Canada
  - 12 in PCT National Phase

- Filed 4 ‘EQUIPMENT’ patents/apps:
  - No “competing prior art”
  - 1 already granted in U.S.
  - Core patent app is in PCT National Phase prosecution in 54 countries

- Follow-on filings are in preparation

Core Competency: Confidential know-how and operating experience

Equipment Patents: Multiple filings with various filter block ‘plate iterations’

Process Patents: Protection of key pretreatment and downstream processes
GreenField’s Pretreatment System Development

• 2012-2013 Milestones:
  - Incorporated the equipment into our Continuous Pilot Plant
  - Established proof of concept
  - Replicated, on a continuous basis, our benchmark batch yield results
  - Operated and optimized the technology and our performance criteria for over 1 year
  - Developed the final pre-commercial scale-up data
2014 Final Development + 2015 Commercial Plan

- **2014: Demo-Scale Mobile System**
  - Capacity = 5 MT/Day

- We are now in the final Pre-Commercial step

- In collaboration with Valmet (formerly Metso) and other equipment suppliers, we built a larger scale mobile System

- We are responsible for procuring all components relating to our IP and for assembling and commissioning the entire System in Chatham for startup by Nov‘14

- By the end of Q1 2015, we will deploy and trial our scaled-up TSE System ‘in-the-field’ at mills in Northern Ontario on 2 platforms – pretreatment (C5 extraction) and solid-liquid separation (sludge)

- By the end of 2015, we will have designed + engineered the Commercial-Scale System for 2016 deployment

- **2016: Commercial System**
  - Flexible capacity – 250 to 1,000 MTDM/day
Mobile Pre-treatment System
Mobile Pre-treatment System
Mobile Pre-treatment System
Mobile Pre-treatment System
Mobile Pre-treatment System
GreenField’s “Best In Class” Pretreatment System

Advantages:

“Biomass Agnostic”
Flexible Biomass:
• Produce Gen 2 Sugars from a diverse variety of biomasses

Scalable Commercial System:
• Initially - process between 250 to 1,000 MTDM/ Day

System Benefits

Optimized Technology Solution
• High C5 + C6 Recovery = High Sugar Yields (no acid)
• Enhanced / Increased C5 + C6 purity, with the least amount of inhibitors
• Average yields are higher than other competitive offerings

Commercially-Sustainable:
• Low CAPEX –
  • i.e. min. 40% reduction in CAPEX compared to more complex equipment trains
• Low OPEX –
  • Lower enzymes and yeast loads required
  • Energy + water efficient

Equipment + Operations
Flexible, Scalable System:
• Can fabricate system and integrate it as the front-end of a host end-to-end cellulosic process to provide best-in-class pretreatment capability

Ease of Operations:
• A complete, reliable, industrial-grade system, supported by equipment warranties and process guarantees
Thank you

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