The sunliquid® process - cellulosic ethanol from agricultural residues
A globally leading company in specialty chemicals

6116
Sales 2014 (CHF m)
from continuing operations

235
Net result 2014 (CHF m)
from continuing operations

4
Business Areas

867
EBITDA 2014 (CHF m)
before exceptionals

14.2%
EBITDA margin 2014
before exceptionals

110 in 60
companies in countries

17,003
Employees 2014
Clariant’s Biotechnology platform offers integrated solutions for bio-based products and processes

Munich
- Since 2006
- 95 employees
- Main R&D center
- Lab and office space: 3,300 m²
- Pilot plant since 2009
- Over 15 different feedstocks tested on pilot-scale

Straubing
- Since 2011
- 22 employees
- Pre-commercial sunliquid plant
- Area: 2,500 m²
- Wheat Straw, Corn Stover, and Sugarcane Bagasse converted to Ethanol
Cellulosic ethanol: Are all processes made equally?

Most processes...

...are based on sugar cane bagasse and/or tops & leaves and/or energy cane
...use enzymes to break down fibers in sugars
...ferment sugars to ethanol
...purify the ethanol

So, why are they different and why are costs different?
Cellulosic ethanol: Are all processes made equally?
With its focus on integration, sunliquid® is designed to achieve optimal efficiency

**Enzymatic hydrolysis**
- High sugar yields through feedstock and process-specific cellulase enzymes
- Integrated on-site enzyme production with biomass as carbon source

**Ethanol Fermentation**
- High ethanol yields with proprietary high-end yeast technology
- Simultaneous one-pot C5&C6 fermentation

**Thermal pre-treatment**
- Chemical-free & low-cost pre-treatment
- Conditions optimized jointly with enzyme production

**Energy integration**
- Side products (e.g., Lignin) as energy sources
- Integration with site-specific energy infrastructure

**Standard equipment**
- Low scale-up risk due to established equipment
- Standard protocols for plant and equipment operations

**Integrated Technology Solution**
- Cost efficient through process design and efficient conversion
- Flexible feedstock input and product output
Over 3 years of validation at the sunliquid® commercial demonstration plant

- Output: 1,000 t/a Ethanol
- Location: Straubing, Germany
- Operational since July 2012
- Feedstock: ~ 4,500 t/a wheat straw, corn stover or bagasse
- Scale-up towards commercial scale only 50x

- Wheat Straw, Corn Stover, and Sugarcane Bagasse converted to Ethanol
- Commercial-scale design confirmed
- Scale-up experience from pilot plant and solution finding
For a 50 kt/a plant, a footprint of approx. 14-18 acres is required.
sunliquid® technology is commercially best in class, competitive vs. 1G ethanol price without incentives

Detailed technology benchmarking study based on technology differentiators

Cost for different technologies

<table>
<thead>
<tr>
<th>Cost for different technologies</th>
<th>Major cost and performance benefits</th>
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<tr>
<td>Total costs per gallon of EtOH with 10 year depreciation</td>
<td>• Integrated enzyme production, no enzyme supply cost and exposure</td>
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<tr>
<td>CLARIANT Sunliquid</td>
<td>• High sugar yield through feedstock and process specific enzymes</td>
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<tr>
<td>Top Competitor A</td>
<td>• High yield fermentation of C6 and C5 sugars into ethanol</td>
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<tr>
<td>Top Competitor B</td>
<td>• Energy saving integrated process design</td>
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<td>Top Competitor C</td>
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<td>Top Competitor D</td>
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<td>Top Competitor E</td>
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1G ethanol price*

* Use Ethanol spot price Chicago Prompt, averaged from 06.2013 to 06.2015. Data from F.O. Licht database.
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For more information on sunliquid® technology visit www.sunliquid.com