Chemtex Group
Global Engineering and Project Solutions

“Case study on the first advanced industrial demonstration bioethanol plant in the EU, and how it was financed”

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Summary

1. M&G vision on renewables
2. The companies involved
3. PROESA® Technology
4. Public funds for demo project
For both **Bio-Fuels** and **Bio-based Chemicals** the solution is based on the same key fundamentals:

1. **Competitive** pricing compared to products from Black Route (at oil prices in the 60-70$/barrel);

2. **Environmentally sustainable** with respect to Green House Gases: overall GHG sequestration balance (including biomass feedstock farming, transportation, chemicals or biofuels production processes);

3. **Agronomically sustainable** on the long term (i.e. no competition with food) and **profitable** for farmers
M&G Group: the companies involved

$3B per year
#2 producer of PET
2,600 Employees
Location: Italy, US, Mexico, Brazil

Engineering division

Technology for biomass to sugars
### Chemtex R&D&D investments on renewables

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Capacity</th>
<th>Location</th>
<th>M&amp;G Investment</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td><strong>R&amp;D Center on Lignocellulosic biomass conversion on Biofuel and Biochemical and development of PROESA® technology</strong> (lab/batch/pilot scale)</td>
<td>Multiple lignocellulosic energy crops and agro residues</td>
<td>50 kg/h of biomass inlet continuous Pilot plants</td>
<td>Rivalta (IT)</td>
<td>€ 160 million</td>
</tr>
<tr>
<td><strong>R&amp;D Centers on Lignin valorization to Biofuel and Biochemical</strong> (lab/pilot/demo scale)</td>
<td>Lignin</td>
<td>Bioreformate, BTX. Production of biofuel and biochemicals</td>
<td>Modugno (IT) Sharon C. (US)</td>
<td>€ 50 million</td>
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<tr>
<td><strong>2nd generation Industrial Bioethanol Demo plant</strong></td>
<td>Arundo donax and Wheat straw</td>
<td>40,000 ton/y Bioethanol</td>
<td>Crescentino (IT)</td>
<td>€ 120 million (CAPEX)</td>
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The **Pillars** of PROESA™ are:

1. **Agronomy**: Field experimentation and best energy crops identified and characterized (12 kinds of biomass tested -> tech biomass agnostic). No biomass drying/grinding required.

2. **Biomass Pre-Treatment and Viscosity Reduction**: Continuous process developed and piloted to produce cost-effective and clean fermentable sugars. Low level of inhibitors. No use of chemicals (only steam is added). Rapid liquefaction of solid content.

3. **Hydrolysis and Fermentation**: Unique hybrid SSCF process scheme yielding high ethanol concentrations. Reduced enzymes load. High solid concentration (>40%) in the hydrolysis step.

4. **Valorization of secondary streams and co-products**.
**PROESA® Technology: the history**

**2006-2008**
- Scouting of Technologies
- Agronomic testing on energy crops
- Generation of key inventions
- Proof of unit operation in lab/batch

**2009-2010**
- PILOT PLANT construction & start up (June 2009)
- Pilot Plant operation and Data gathering
- Test of plant flexibility using multiple biomasses

**2011-2012**
- Crescentino 40,000 ton/y INDUSTRIAL DEMONSTRATION ETHANOL PLANT
- Technology licensing
Key advantages of PROESA® technology

**Financial:**
- Lower capital investment as a result of minimum handling of biomass, simplified flow schemes and no special materials of construction;
- Cash cost of fermentable sugars at ~10 ¢/lb;
- Cash cost of ethanol of <$ 1.50/USG ($ 0.40/L);
- Cost-effective at modest scale; short supply chains
- Beta Renewables: joint venture Chemtex-TPG
- Strategic partnership making Novozymes the preferred enzyme supplier for Beta Renewables’ current and future cellulosic biofuel projects.

**Flexibility:**
- Feedstock-agnostic: energy crops, agricultural residues, organic waste, woody biomass, bagasse;
- Deployable worldwide;
- Pure lignin by-product to be valorized to energy or renewable chemicals.
- Commitment of Chemtex and its partners to continuous development and improvement

**Competitive and attractive economics without subsidies**
Three points that will change the industry

- **Commercial-scale** cellulosic ethanol plant, Q3 2012: 40,000 ton/y, Crescentino - Italy (ready to start)
  - Cellulosic **costs less**
  - **No subsidies** required
• 120 M€ of investment
• 40’000 Mtons Second generation Bioethanol
• 160,000 ton/y of dry lignocellulosic biomass
• 13 MW of green power from lignin
• 300 pieces of equipment
• 1’500 tons of steel
• 1’400 tons of pipes and valves
• 30’000 m³ of concrete
• 18 km of underground piping
• More than 150 persons involved directly
• Commissioning: December 2012
How can research and its scale-up be founded?

Basic and applied research (lab/batch)

PILOT SCALE

DEMONSTRATION PLANT

First-in-its-kind PRE-COMMERCIAL PLANT

INDUSTRIAL COMMERCIAL PLANT

European (FP7, NER300, IEE, Life+, ...) and National funds
PROESA® technology scale-up

- Ideas
  - Technical feasibility
    - Technical feasibility confirmation
    - Market opportunity
    - Economics

- PoP
- Lab Scale
  - Detailed technical feasibility confirmation
  - Production cost evaluation
  - Market opportunity confirmation

- Pilot Scale
- Demo Unit
  - Reduction of industrial risk
- Industrialization
  - Process and product are demonstrated
  - Basic

- RTD
- RTD pilot
- DEM
- PRECOM
- COM
Public funds for demonstration project – the Bioethanol case

- **Project PRIT**
  - Approved by Industria 2015
  - Pretreatment

- **Project BIOLYFE**
  - Approved by FP7
  - Enzymatic Hydrolysis
  - Fermentation
  - Separation

- Demo Plant Construction

- **RTD**
  - RTD pilot

- **DEM**

- **PRE-COM**

- **COM**

- **NER 300**

- **REGIONE PIEMONTE**

- **INDUSTRIA 2015**
Chemtex next demonstration projects

**PROESA® Technology**

LOW COST SUGAR C5-C6 PLATFORM

New Tech → BIOFUEL

New Tech → Biochemicals

BIOFUEL
- Ethanol
- Bio-Jet fuel
- Marine Diesel
- Green Diesel
- Butanol

New Tech → BIOCHEMICAL

BIOCHEMICAL
- Acrylic Acid
- Fatty Alcohols
- Succinic Acid
- 1,4 Butanediol
- Acrylic Acid
- Farnasene
- Bio-PE
- Bio-EO/EG

LIGNIN-CHEMICALS
- Benzen
- Phenols
- Xylene
- Terephthalic Acid
- Aromatic aldehydes

LIGNIN PLATFORM

New Tech → BIOFUEL

New Tech → Biochemicals

DEMO/ PRE-COMMERCIAL

DEMO/ PRE-COMMERCIAL

DEMO/ PRE-COMMERCIAL
THANK YOU