Industrial experience in Second Generation Ethanol production

4th Bioenergy Week
Beta Renewables Overview

Beta Renewables is a joint venture, created in October 2011, between Biochemtex and the investment firm TPG (Texas Pacific Group); Novozymes, Denmark-based world-class biotech company acquired 10% share of Beta Renewables in October 2012.

Beta Renewables owns and licenses the PROESA™ technology.

Beta Renewables owns and operates the 1st commercial-scale 2G bioethanol plant in Crescentino (Italy).
Mossi & Ghisolfi Group was founded in 1953 to produce packaging for detergents and toiletries, mainly from HDPE and PVC.

- M&G Group today is the largest privately owned chemical company in Italy.
- It is one of world top 3 producer of PET for packaging and polyester fibers.
- Today is a leader in sustainable chemistry and biofuels.
A solid family of companies

Polymers
One of the top 3 PET producers worldwide.

Engineering and R&D
60 years of excellence in process development and commercialization of plants

Green Chemistry
PROESA™: technology leader in biofuels and chemical intermediates from non-food biomass
**PROESA™ Technology - The Process**

**PROESA™ Technology benefits:**

- Feedstock flexibility
- Innovative proprietary continuous biomass cooking process with no chemicals addition
- Unique process design for a constant and continuous liquefied sugars stream production, together with Novozymes enzyme action
- Fully integrated process design using continuous equipment to enable large scale plants
- Best in class technology with lowest CAPEX and OPEX backed with process and performance guarantees
### Timelines of our development

#### 2006-2008
- Scouting of Technologies
- Generation of key inventions
- Proof of UNIT OPERATION in the labs

#### 2009-2010
- Pilot plant (1 t/day) construction & start up (June 2009)
- Pilot Plant operation and data gathering
- Test of Plant flexibility using multiple biomasses

#### 2011-2012
- Start of Construction at Crescentino
- Formation of Beta Renewables
- Investment by Novozymes in BetaR
- Collaboration Agreements with leading synthetic biology companies
- Test of Plant flexibility using multiple biomasses

#### 2013
- Crescentino Plant Start-up
- USDA loan guarantee for US Project (Alpha in NC)
- Continued joint development and co-marketing with Novozymes
- Partnership with Lesaffre for yeast technology

#### 2014-16
- Crescentino operating at steady state & within design parameters
- GranBio (PROESA™ project #2) Start-up
- China Project JV Formation
- MoU with CVC for 2G project in Punjab and Gujarat (India)
- First european licence - Energochemica (Slovakia)
- Strategic partnership with Valmet for lignin valorisation
PROESA™ Intellectual property

PATENT PORTFOLIO FOCUSED ON:

✓ Key innovative process steps
✓ Cost effective solutions
✓ Solutions for specific applications
✓ Integrated processes and related products
✓ Equipment design
✓ Streams valorization at industrial scale

26 patent families with KEY APPLICATION filed in over 50 COUNTRIES
PROESA™ technology on a global scale
Crescentino Site ...  

..... The past
Foundry for automotive (Fiat Group)

...The present:
A first-of-a-kind Biorefinery
Operating industrial plant

Apr 2011

Dec 2012

Sept 2011

January 2013

Operating at Industrial scale
PROESA™ Technology
Crescentino the site in numbers...

- Footprint of 15 Ha
- Capacity: 40,000 Mt/yr of Ethanol
- 13MW green electricity
- 100% water recycle = zero water discharge
- 100 operators on staff

Some interesting facts:
- First Cellulosic ethanol Commercial plant in the world
- Zero incidents since its start up
- Off-take agreement with Premium on T2
First years of operations 2013 – 2015

2013: Plant start up, first ethanol produced, biomass mainly used wheat straw. Recognition of technical issues related to equipment design + feedstock. First round of modifications

2014: Recognition of bottle neck issues and second round of modifications. New generation of yeast and catalyst

2015: Introduction of other feedstocks (rice straw, woody biomass) Plant operated steadily with process stability Plant operability index greatly improved Production rump up

✓ From unstable to stable plant with extensive process implementation
**Enzymatic Hydrolysis Development**

- **New enzymes have been studied and improved** along the years from Crescentino hydrolyzate together with Novozymes
- History of Novozymes enzymes improvement is reported:

  ![Enzyme cost efficiency development](image)

  - Improvement of the biocatalyst is an area of continuous active R&D activity with our partner Novozymes and we anticipate delivering cost reductions to our licensees over time while new process solutions have been implemented to guarantee an optimal enzyme-substrate interaction.
Plant operability

- The lesson learned during these two years of plant operation, led to recognize the main plant issues and where to focus in order to have plant stability and continuous production

- From unstable plant to stable plant with an extensive implementation of process development

- Key parameters improvements based on running experience

Operability Index * related to plant availability

*Operability Index is defined as number of days in which the plant is running up to the number of days of plant available (excluding stop for external causes)

Plant operability was kept constant since the beginning of 2015 at values > 90%
**Crescentino feedstock**

**PURE**
- Wheat straw
- Arundo donax
- Rice Straw
- Poplar

**MIX**
- Wheat straw + Arundo Donax
- Wheat straw + Rice Straw
- Wheat straw + Wood Scraps
Processing wood in Crescentino

- Based on the positive results obtained in Rivalta Pilot plant, we run first Industrial Test in November 2015 using Poplar.
- The results confirmed the positive trend of the R&D Center.
- Poplar is easily available and cost competitive.
- No need to be washed prior the Pre-treatment.

In May 2016 we have run a long campaign in Crescentino with a mix of hardwoods (Poplar mainly).
The Biorefinery Concept

Biomass

PROESA®

Cellulosic Sugars

C5-DERIVED CHEMICALS
C6-DERIVED CHEMICALS
(C5+C6)-DERIVED CHEMICALS

NOW

N-Butanol
Iso-Butanol
Butanediol
Fatty Alcohols
Ethylene Glycol

Ethanol

NEXT

POTENTIAL

Lignin

ENERGY

LIGNIN-DERIVED CHEMICALS

Aromatics
Terephthalic Acid
Phenols

Power

Heat / Steam

CRESCENTINO

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New Technologies on development...

New technologies for sugars conversion and lignin processing are on development in our R&D facilities

- Biomass
- PROESA® Technology
- C6 Sugars
- Fermentation units
- Separation
- C5 Sugars
- Fermentable Sugars
- Lignin
- MOGHI Technology
- Fuel/Chemicals
- BTX PTA
- Aromatics
- Glycols (MEG and MPG)
- GREG Technology
- Chemicals

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Thank you!

giuliano.ghiglione@gruppomg.com

Beta Renewables S.p.A.
Strada Ribrocca, 11 - 15057 Tortona (AL), Italy
Ph. +39-0131-810369
www.betarenewables.com