PROESA™
A superior technology for the production of fermentable sugars for conversion to ethanol and specialty chemicals from Cellulosic Biomass
Chemtex Offices

Chemtex Italy
Tortona, Rivalta

Chemtex China
Shanghai, Beijing

Chemtex USA
Wilmington N.C.
Sharon Center, OH.

Chemtex India
Mumbai, Bangalore

- Annual Turnover: USD 300 MM
- Employees: 1000
# Gruppo Mossi & Ghisolfi

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>1950</td>
<td>M&amp;G was founded in 1953 by Vittorio Ghisolfi in Tortona, Italy</td>
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<td>1960</td>
<td>Packaging Manufacturing Phase</td>
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<tr>
<td>1970</td>
<td>M&amp;G offered customers packaging from HDPE and PVC</td>
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<td>1980</td>
<td>Chemical Specialty Manufacturing Phase</td>
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<td>1990</td>
<td>Group activities were integrated upstream in the development and</td>
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<td>production of special resin (PET) for food packaging applications</td>
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<td>2000</td>
<td>Acquisition of Shell’s PET business</td>
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<td>2002</td>
<td>Acquisition of Brazilian controlled Rhodia-ster from Rhone Poulenc</td>
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<td>2003</td>
<td>Start up of world’s largest PET production unit at Altamira (Mexico)</td>
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<td>2004</td>
<td>Acquisition of the world class engineering group Chemtex from</td>
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<td>Mitsubishi Corporation</td>
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<td>2005</td>
<td>Start-up of highest capacity single line PET production plant in</td>
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<td></td>
<td>Suape, Brazil</td>
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<td>2006</td>
<td>A Chemtex EPC Project</td>
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<td>2007</td>
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**PET Expansion Phase**
Center for Renewable Resources

- 32,000 Ft² dedicated to fuel chemistry and technology from renewable resources
- Fully equipped analytical and fermentation laboratories
- Pilot Plant
- 50 staff dedicated to R&D activities
Biorefinery Concept - Today

- Cellulose: 45%
- Lignin: 30%
- Hemicellulose: 25%

- Energy

- C5 sugars
- C6 sugars
- Lignin

- Ethanol
Catalytic conversion of sugars

- Catalytic Dehydration
  - Ethanol to ethylene
  - Technology available

- Catalytic Hydrogenolysis
  - Glycols to sugars
  - Technology available

- Catalytic Deoxygenation
  - Glycols from pentoses
  - Development phase

- Oxidative Dehydrogenation
  - Polyols to olefins
  - Process under investigation

- Catalytic Oxidation
  - Lignin to phenols
  - Development phase
  - Lignin to aromatics
  - Process under investigation
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 USD $60-$70/Bbl range);

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)

4. **Profitable** for farmers to grow biomass feedstock
The Three Pillars of PROESA™ are:

1. **Agronomy**: Field experimentation and best energy crops identified and characterized.

2. **Biomass Pre-Treatment and Viscosity Reduction**: Continuous process developed and piloted to produce cost-effective and clean fermentable sugars.

3. **Hydrolysis and Fermentation**: Unique hybrid SSCF process scheme yielding high ethanol concentrations.
Pre-Treatment
Typical process yield

Kg dry biomass/Kg of Ethanol

- Giant reed (Arundo donax)
- Wheat straw
- Rice straw
- Miscanthus
- Sugar cane bagasse
- Corn stover

Process conditions under optimization
Agronomy

Our Philosophy:

✓ Respect of the environment
✓ No competition between Fuel vs. Food
✓ Easy to insert into the traditional agronomic system and biomass market

Our Approach to Sustainability

✓ High yielding species
✓ High biomass to bioethanol conversion
✓ Biomass requiring low inputs (chemicals & utilities)
✓ Agricultural residues
✓ Optimization of agronomic systems (cultivation-logistics-transportation)
Agronomy and Logistics

- Availability of 150 acres for R&D related to energy crops
- R&D activities selected the best energy crops for ethanol production.
ENERGY CROPS – Herbaceous Energy Crops

The most promising herbaceous crops are Arundo donax, Miscanthus giganteus, Sorghum and Panicum virgatum. These are the species that we have studied in our experimentation.
>10 year old *Arundo donax* stand at OSU
2010 yield 19.8 bdt/acre
Since the 40s Italy has industrial experience in exploitation of Arundo donax for textile industries, (Average yield of 30 t/ha d.m. with no selection of ecotypes and using traditional non automated cultural techniques)

12000 acres during a 30 year period
**Arundo Donax** - yields high dry matter with minimal fertilizer and water.
Agronomic experimentation: ecotypes selection and plot evaluation

Best 14 ecotypes 2007

1st Year - yield [dry ton] / ha

Productivity dry ton/ha

SMERALDO  GIADA  AGATA  MAGNESITE  IOLITE  ZAFFIRO  TURCHESE  AMBRA  QUARZO  EUDIALITE  ONICE  PIRITE

ecotypes number

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89
Agronomic experimentation: ecotypes selection and plot evaluation

Best 4 ecotypes 2008

2nd Year - yield [dry ton] / ha

- RUBINO
- IOLITE
- TURCHESE
- EUDIALITE

Productivity: dry ton/ha
2010 Test - Evaluation of different propagation systems

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<thead>
<tr>
<th>methods</th>
<th>advantages</th>
<th>disadvantages</th>
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| Rhizome          | • safest way to propagate  
                  • no need to water after planting  
                  • good production the first year                                 | • one year of nursery for rhizome reproduction  
                  • can be planted only in spring                                      |
| Stem             | • can be planted from autumn to spring  
                  • no need of nursery  
                  • easy to establish                                             | • lower productivity on the first year  
                  • Irrigation or rain is required after planting                      |
| Micropropagation | • quick reproduction of propagules  
                  • Potentially cheap  
                  • easy to establish (tomato/tobacco planter)                       | • lower productivity on the first year  
                  • use of greenhouse for acclimatization before planting  
                  • irrigation is required during the first year                    |
Thanks to *Arundo donax* adaptability it can be harvested throughout the growing season. This is very useful for the logistics of the plant.

2009 Test - Evaluation of multiple harvest

First cutting July 20

Regrowth after one month
After a 10-year cycle the rooting system can be easily removed by a chemical – mechanical combined system:
   a) Glyphosate spraying after the last cut
   b) mechanical rhizome removal with root rake or potato harvester
2011 Text of Arundo on reclaimed Surface Mine land

WVU/WVEPA/WVDOE

Biofuels plots at Alton West Virginia
CONTROL OF SPREADING

Every 2-3 years maintenance of the border of about 3 yards around the field is enough to avoid any uncontrolled spread.
PROESA™ – Summary

A superior technology for the production of fermentable sugars and/or ethanol from Cellulosic Biomass

- 2006 - 2008
  Scouting, testing and development of technology on lab scale

- 2009
  Construction and tests on continuous pilot plant

- 2011
  Construction of Demonstration Plant
  40 ktpa (16 MGY)

- 2012+
  A Game Changer for the production of Drop-in Fuels, Biochemicals and Ethanol
From Petrochemistry to Green Chemistry
THANK-YOU FOR YOUR ATTENTION!