# Chemtex Group

***Global Engineering and Project Solutions***

## PROESA™

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

***December 2011***

# Chemtex Offices

## Chemtex Italy

Tortona, Rivalta

## Chemtex China

Shanghai, Beijing

## Chemtex USA

Wilmington N.C.

Sharon Center, OH.

- Annual Turnover: USD 300 MM
- Employees: 1000

## Chemtex India

Mumbai, Bangalore

# Gruppo Mossi & Ghisolfi

1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007

M&G was founded in 1953 by Vittorio Ghisolfi in Tortona, Italy

**Packaging Manufacturing Phase**

M&G offered customers packaging from HDPE and PVC

**Chemical Specialty Manufacturing Phase**

Group activities were integrated upstream in the development and production of special resin (PET) for food packaging applications

**PET Expansion Phase**

- **2002** – Acquisition of Shell's PET business
- **2003** – Acquisition of Brazilian controlled Rhodia-ster from Rhone Poulenc
- **2004** – Start up of world's largest PET production unit at Altamira (Mexico)
- **2005** – Acquisition of the world class engineering group Chemtex from Mitsubishi Corporation
- **2006** – Start-up of highest capacity single line PET production plant in Suape, Brazil

*A Chemtex EPC Project*

# Center for Renewable Resources

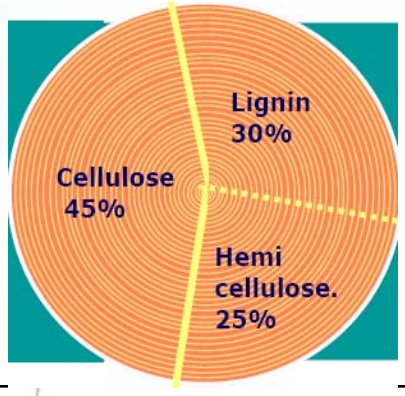
32000 Ft$^2$ dedicated to fuel chemistry and technology from renewable resources

Fully equipped analytical and fermentation laboratories

Pilot Plant

50 staff dedicated to R&D activities

# Biorefinery Concept - Today




C5 sugars

C6 sugars

**Ethanol**


Lignin

Energy

# Catalytic conversion of sugars

| | | |
|---|---|---|
| Catalytic Dehydration | • Ethanol to ethylene | • Technology available |
| Catalytic Hydrogenolysis | • Glycols to sugars | • Technology available |
| Catalytic Hydrogenolysis | • Glycols from pentoses | • Development phase |
| Catalytic Deoxygenation | • Polyols to olefins | • Process under investigation |
| Oxidative Dehydrogenation | • Lignin to phenols | • Development phase |
| Catalytic Oxidation | • Lignin to aromatics | • Process under investigation |

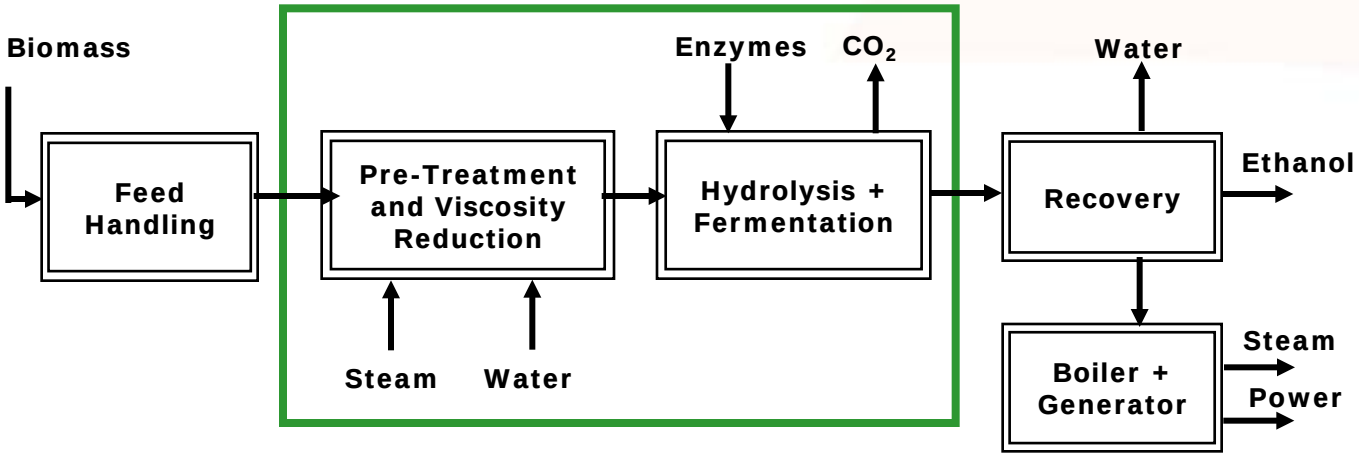
# The M&G Vision

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

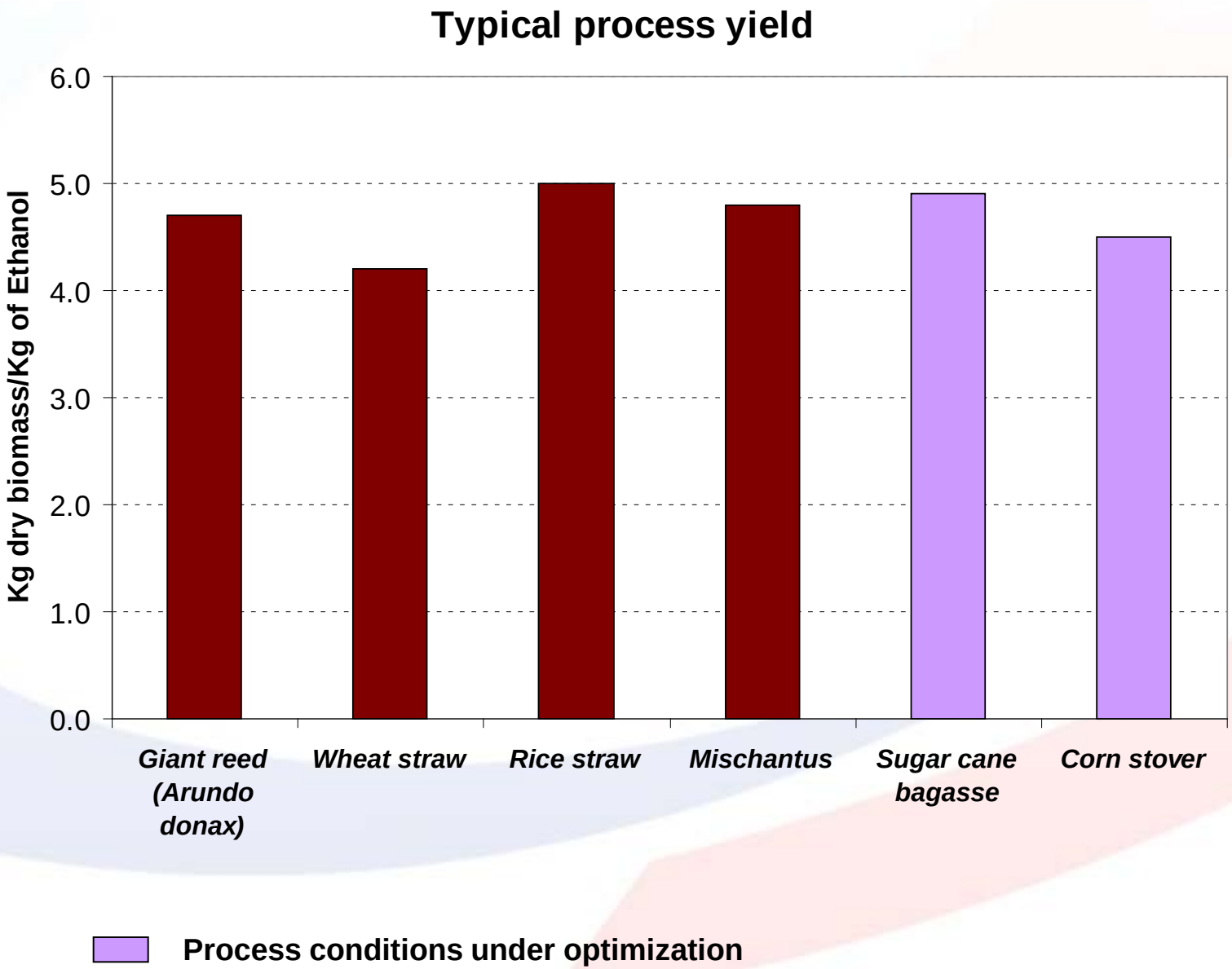
# PROESA™ - The Technology




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
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Giant reed (Arundo donax)
Wheat straw
Rice straw
Mischantus
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.


Arundo donax


Miscanthus "Giganteus"


Sorghum ( Fiber and Sweet )


Panicum virgatum

# >10 year old Arundo donax stand at OSU
# 2010 yield 19.8 bdt/acre

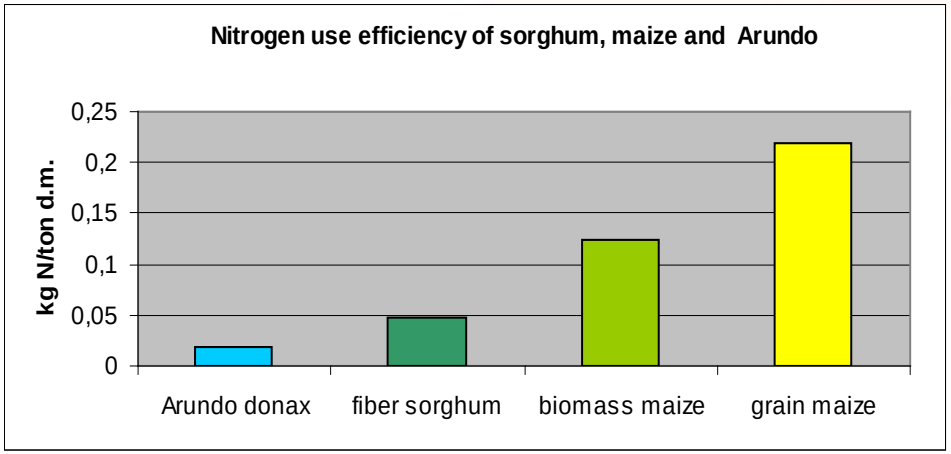
# ARUNDO DONAX – STATE OF THE ART

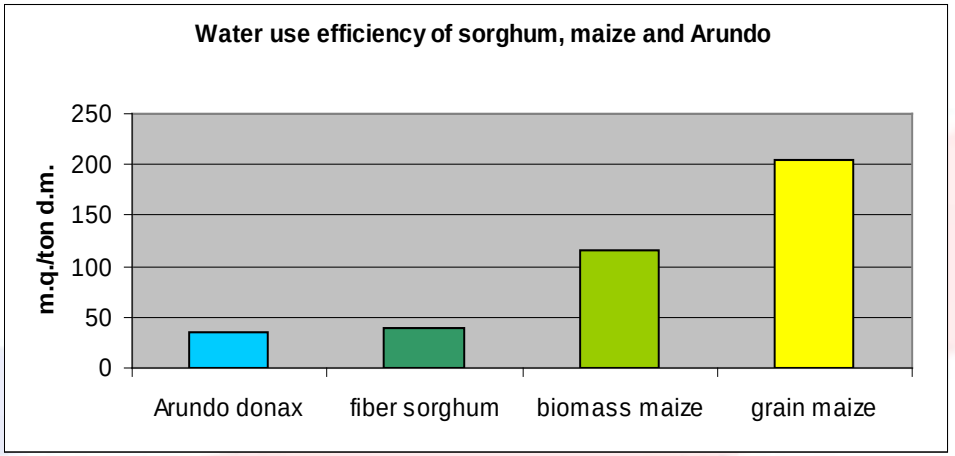
- Since the 40s Italy has industrial experience in exploitation of Arundo donax for textile industries, (Average yield of 30 t/ha d.m. with no selection of ecotypes and using traditional non automated cultural techniques)

12000 acres during a 30 year period

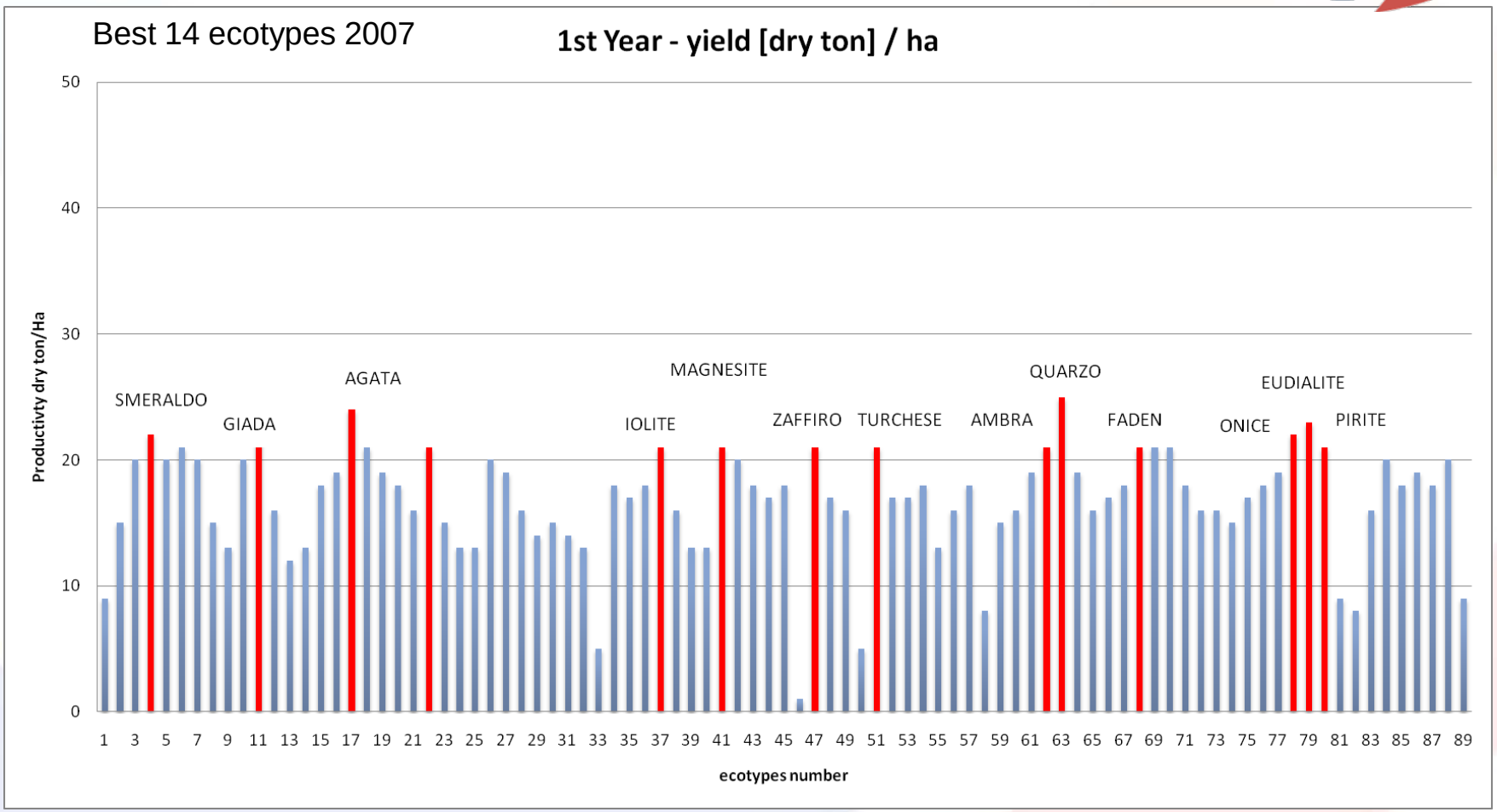

# Arundo Donax Characteristics

***Arundo Donax*** - yields high dry matter with minimal fertilizer and water.



# Agronomic experimentation: ecotypes selection
## and plot evaluation



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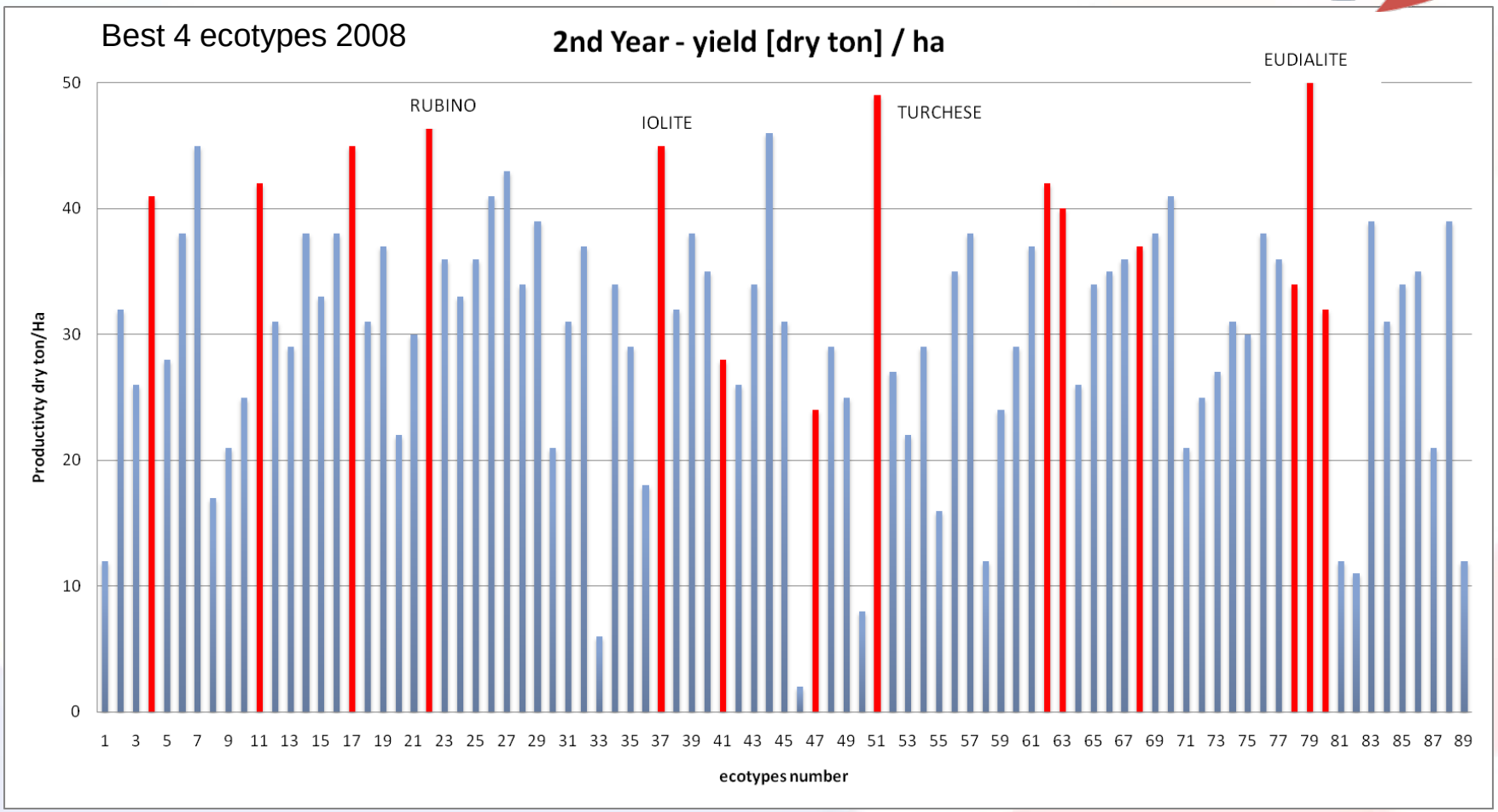
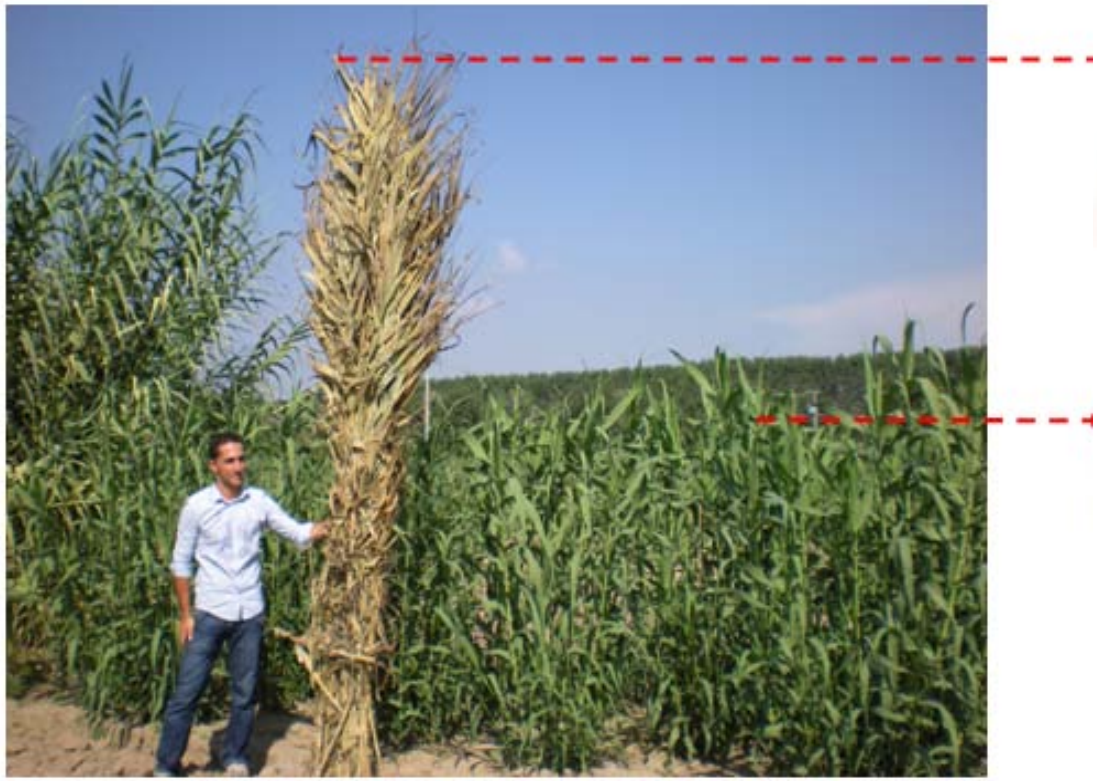


# 2010 Test - Evaluation of different propagation systems

| methods | advantages | disadvantages |
|---|---|---|
| Rhizome | • safest way to propagate<br>•no need to water after planting<br>• good production the first year | • one year of nursery for rhizome reproduction<br>•can be planted only in spring |
| Stem | • can be planted from autumn to spring<br>•no need of nursery<br>•easy to establish | •lower productivity on the first year<br>•Irrigation or rain is required after planting |
| Micropropagation | • quick reproduction of propagules<br>• Potentially cheap<br>• easy to establish (tomato/tobacco planter) | • lower productivity on the first year<br>• use of greenhouse for acclimatization before plasnting<br>• irrigation is required during the first year |

# 2009 Test - Evaluation of multiple harvest



First cutting July 20

Regrowth after one month

Thanks to *Arundo donax* adaptability it can be harvested throughout the growing season. This is very useful for the logistics of the plant.

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

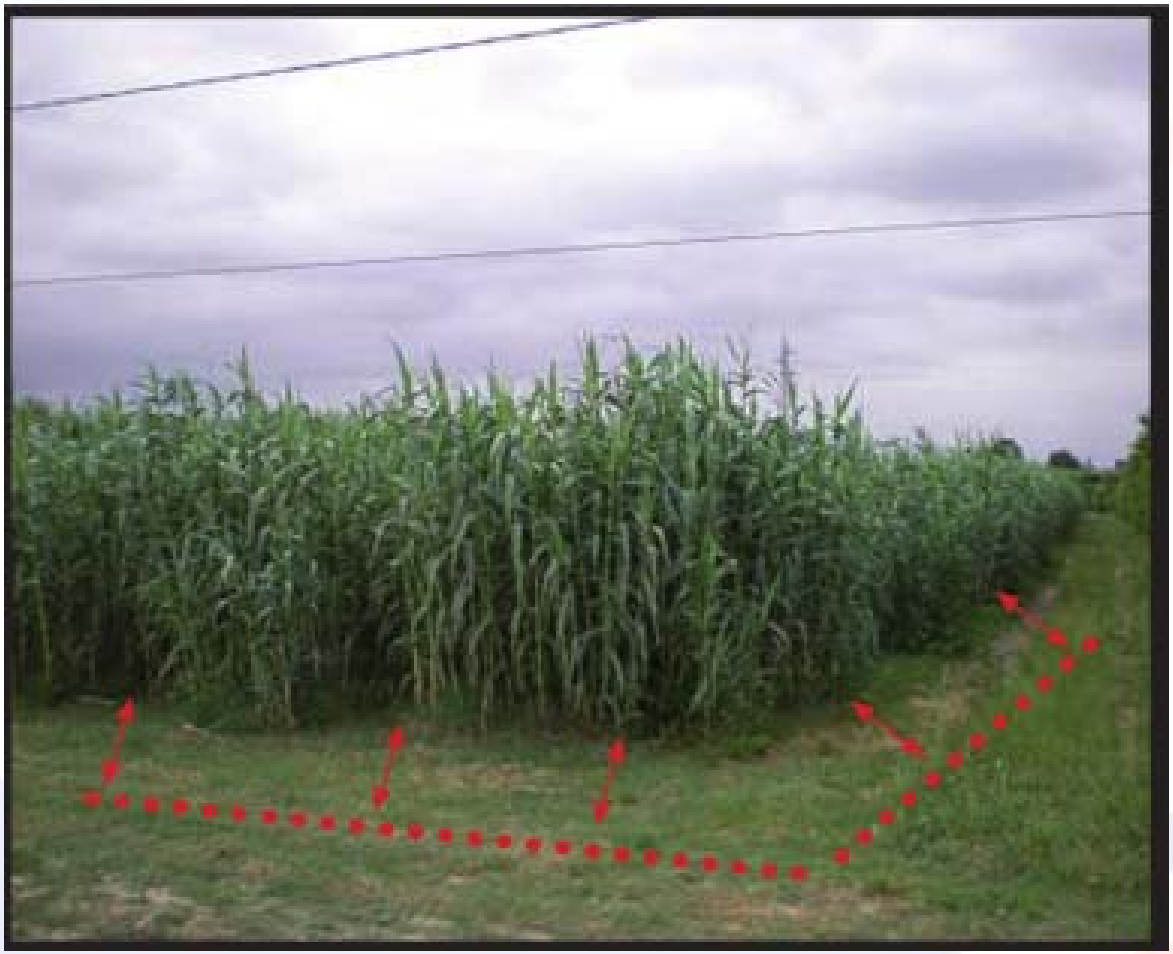
20 cm thickness

2011 Text of Arundo on reclaimed Surface Mine land

WVU/WVEPA/WVDOE

Biofuels plots at Alton West Virginia

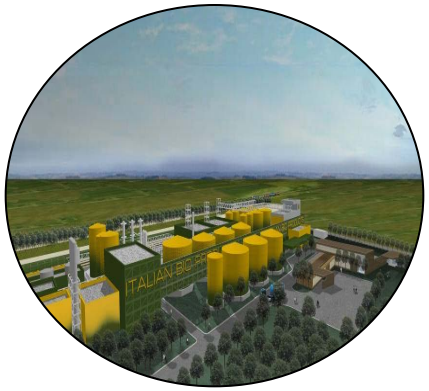
# CONTROL OF SPREADING



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



A Game Changer for the production of Drop-in Fuels, Bio-chemicals and Ethanol

**2006 - 2008**

Scouting, testing and development of technology on lab scale

**2009**

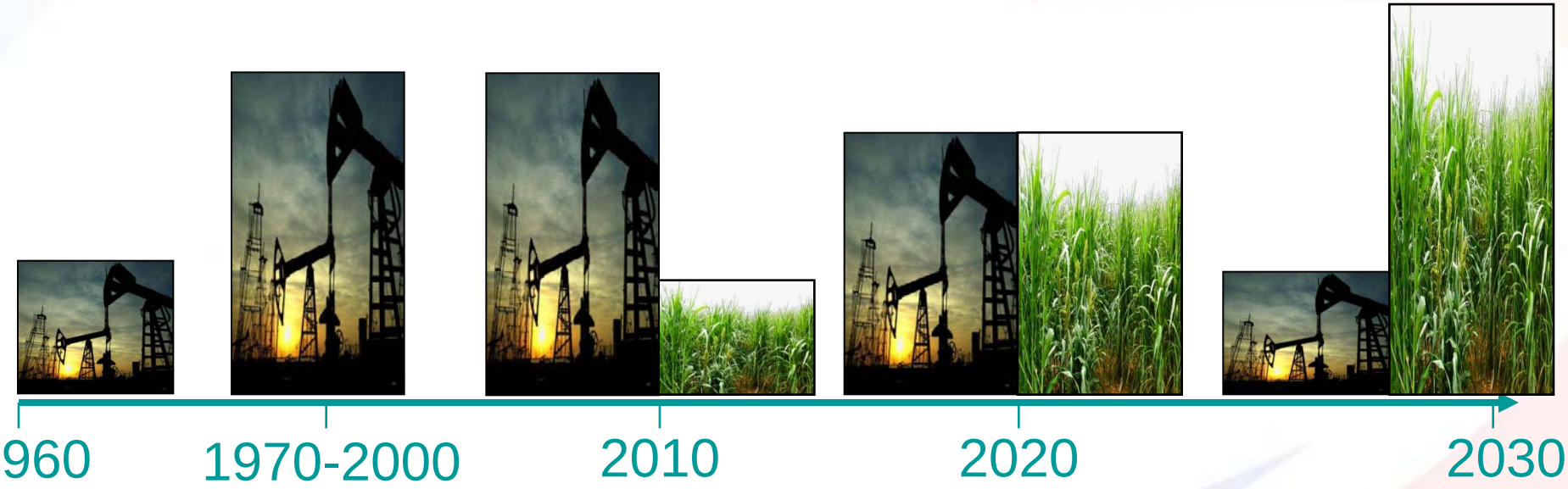
Construction and tests on continuous pilot plant

**2011**

Construction of Demonstration Plant 40 ktpa (16 MGY)

**2012+**

# From Petrochemistry to Green Chemistry



# THANK-YOU FOR YOUR ATTENTION!

CHEMTEX

M&G
GRUPPO MOSSI & GHISOLFI

growing
Energy