



# Biorefineries and green chemistry in Italy: an overview of applied R&D, demo and industrial breakthroughs

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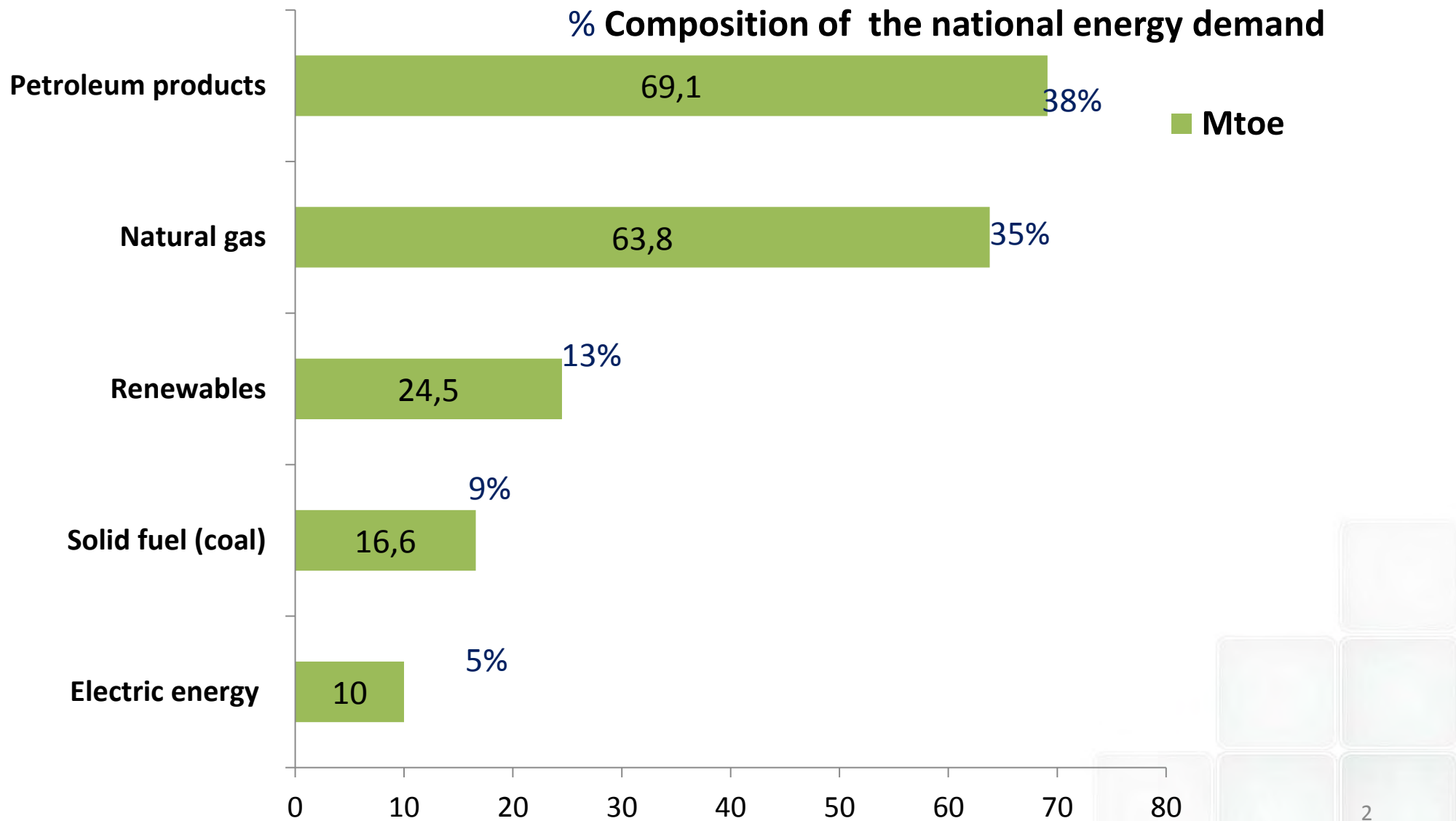
**Austrian stakeholders meeting,  
24 october 2013  
GRAZ**

# ITALY – NATIONAL ENERGY DEMAND IN 2011

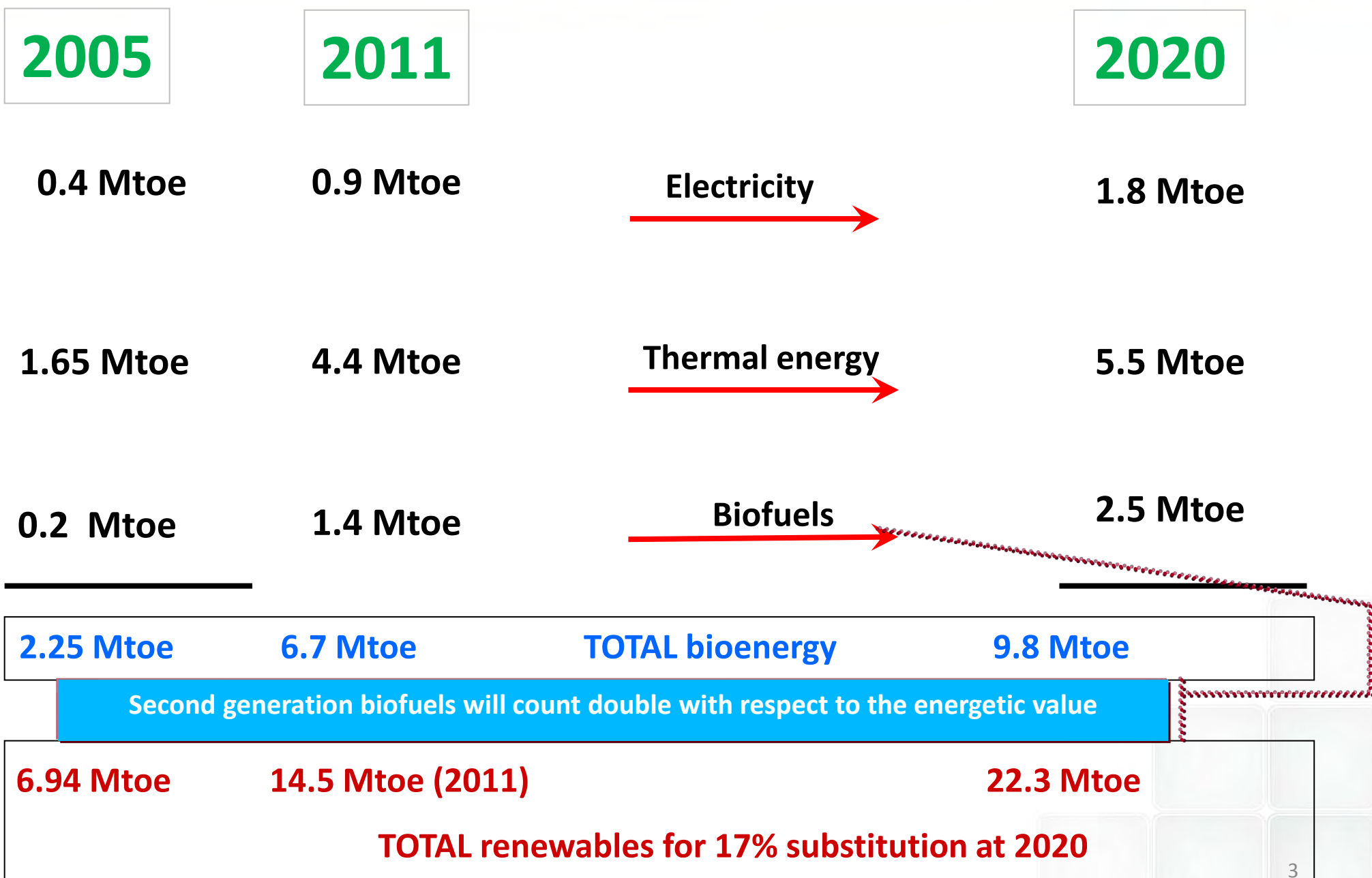


Total energy demand in 2011: 184 Mtoe

% Composition of the national energy demand



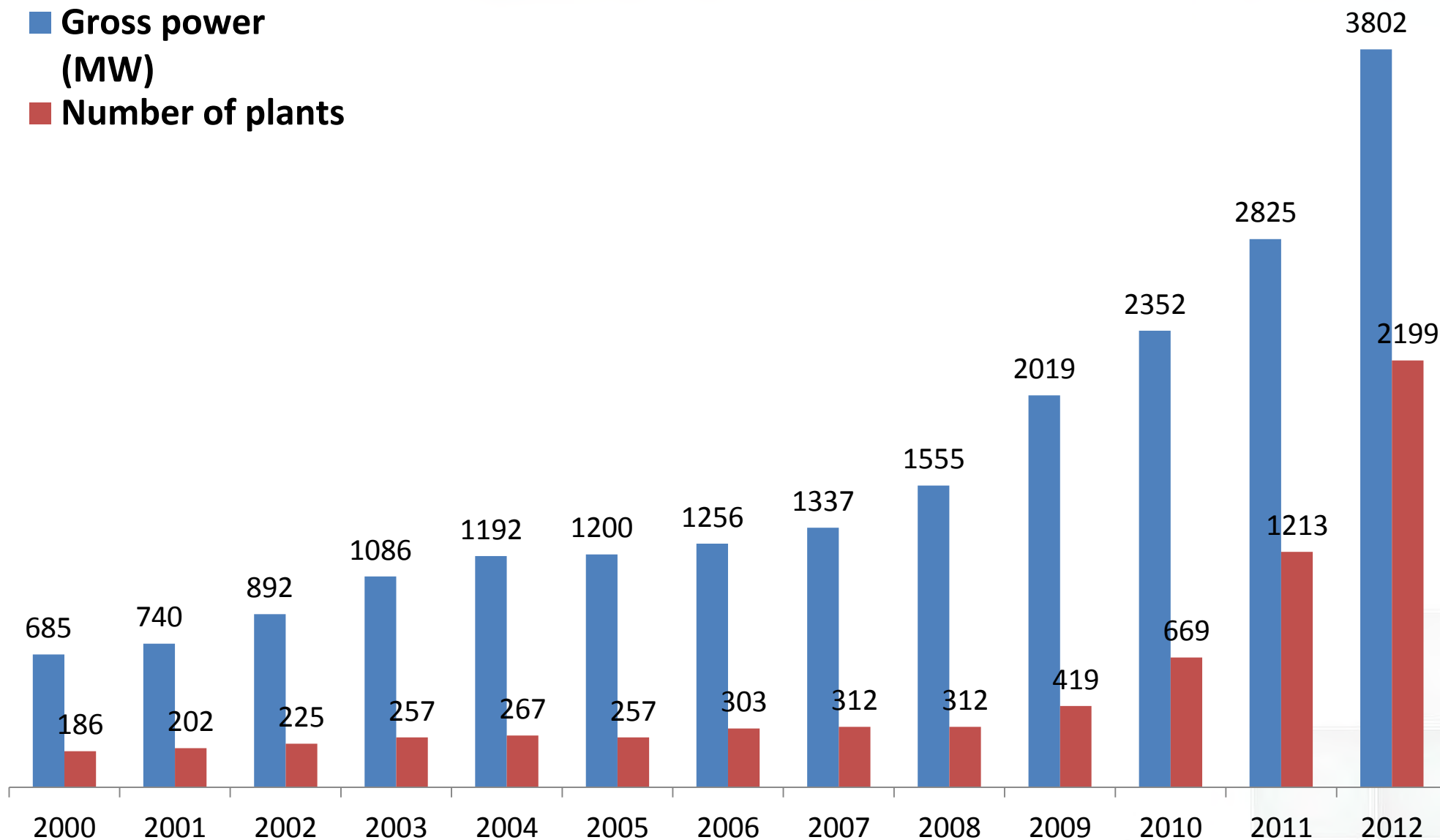
# ITALIAN ACTIONS PLAN FOR THE RENEWABLE ENERGIES/BIOMASS AND BIOENERGIES



# PRODUCTION OF ELECTRIC ENERGY FROM BIORESOURCES IN ITALY



■ Gross power (MW)  
■ Number of plants



# BIOMASS POTENTIAL IN ITALY AND AVAILABLE BIOMASS

	SOURCES					
	[10]	[40]	[38]	[39]	[41]	[42]
<i>Forestry</i>	167	38	180	247	121	544
direct wood	167	38	138	176	100	448
indirect wood	0	0	38	71	21	96
<i>Agriculture</i>	272	406	502	611	285	234
crops	67	406	373	188	13	4
by-products	205	0	130	423	272	230
<i>Waste</i>	100	25	113	201	176	67
MSW	75	25	50	75	92	17
industrial	25	0	50	100	42	42
sewage sludge	0	0	13	25	8	8
<b>Total</b>	<b>540</b>	<b>469</b>	<b>783</b>	<b>1055</b>	<b>553</b>	<b>846</b>

Source:  
*Renewable Energy 57 (2013) 448-461*

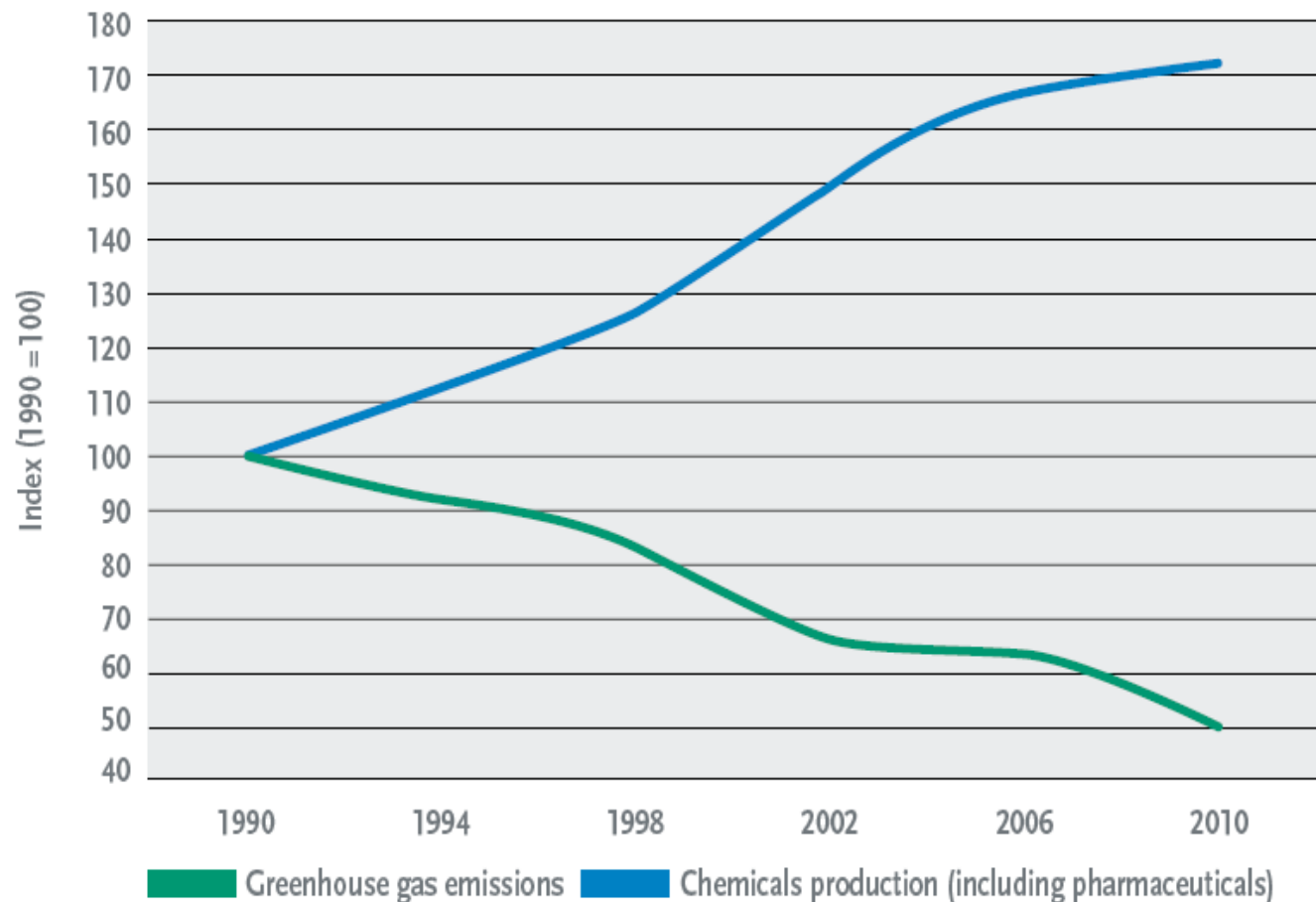
National Renewable Energy Action Plans, 2011

Data from the ENEA's ITALIAN BIOMASS ATALS

From several estimations 783 PJ - 1055 PJ biomass might be available in Italy

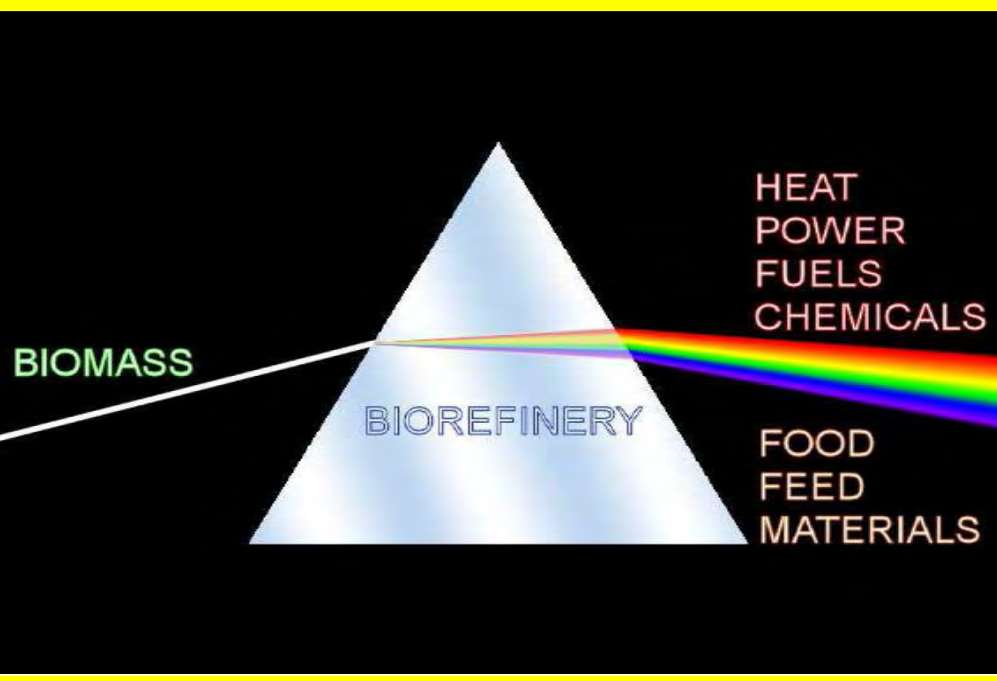
# NEW PERSPECTIVES FOR THE CHEMICAL INDUSTRY FROM THE “GREEN” ECONOMY

In Italy, in 2011, the overall production of the chemical Industry was 52 bl€ ~ 9.7% of the European  
In 2012 a contraction of 3% in value and 5% in volume occurred. The desired targets for the chemical industry is a progressive reduction of the greenhouse gas emissions and of the energy consumption of the industrial processes



Source: Cefic Chemdata 2012

# BIOREFINERIES AND GREEN CHEMISTRY



Biorefineries are the practical way to sustainable development through a wide spectrum of bio-based and “green” products.

45 biorefineries could imply ~ 9 billions euro of investments, 90/100 million men/hours for plants installation, 90/100 million men/hours for plant facilities and plant instrument/devices, about 10.000 of jobs (direct) and about 30.000 indirect jobs

Energy driven biorefinery



- Bioemethane, Bioethanol, biodiesel, electricity and heat

PRODUCT DRIVEN

*green-chemicals, materials (bioplastics)*



- Biolubricants
- Biosuccinic acid
- bioplastics
- Levulinic acid
- Additional Carboxylic acids

# BIOFUELS DRIVEN BIOREFINERIES

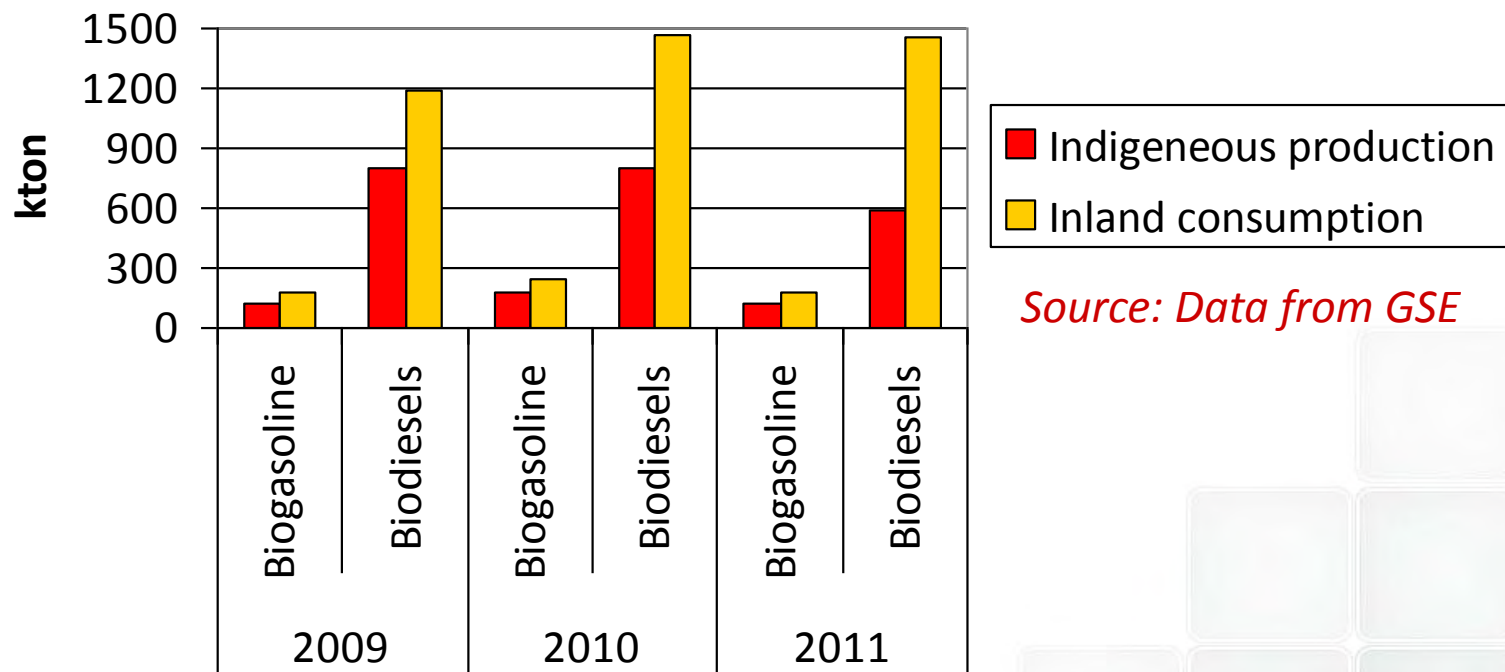
## Biofuels target

Year	Biofuel
2008	2%
2009	3%
2010	3.5%
2011	4%
2012	4.5%
2013	5%
2014	5.5%

❑ Biodiesel installed capacity is 2.4 million tonnes (15 biodiesel plants)

- ❑ The share of imported biodiesel is increasing
- ❑ The raw material used for biodiesel is mainly imported as oil.

❑ The bioethanol production in Italy has only, up to now, been based, on the distillation of wine and vegetable and fruit products.



Source: Data from GSE

**Biogasoline:** bioethanol + biomethanol + bioETBE (47%) + bioMTBE (36%).

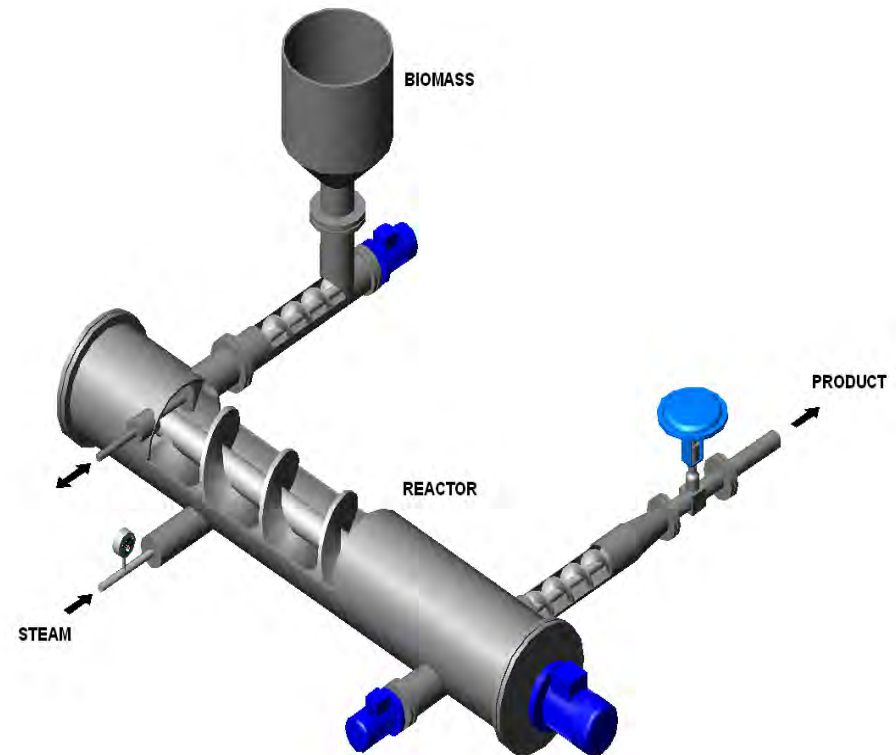


# PRODUCTION OF 2G BIOETHANOL

*Steam explosion* can be considered a versatile technology since it produces high degrees of biomass destructuration and facilitates the subsequent fractionation in its macrocomponents.



**STEAM EXPLOSION PILOT STATION AT ENEA TRISAIA IN ITALY (300 kg/h)**



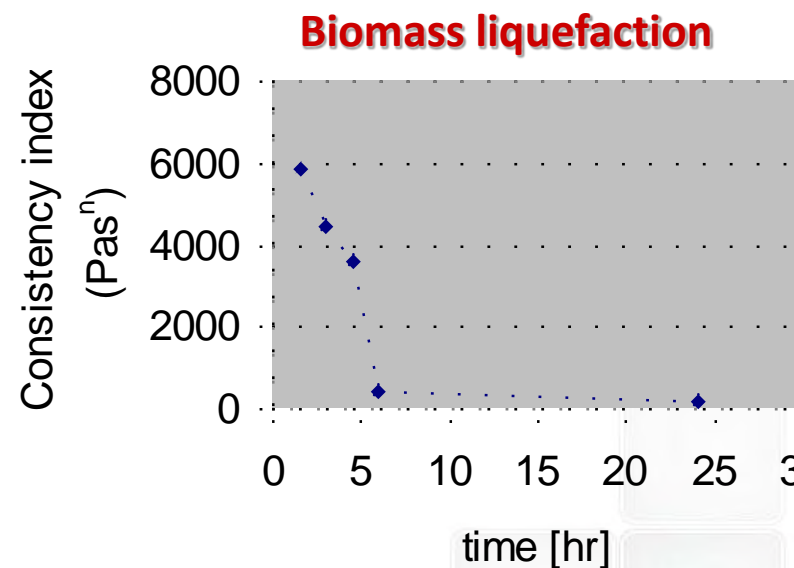
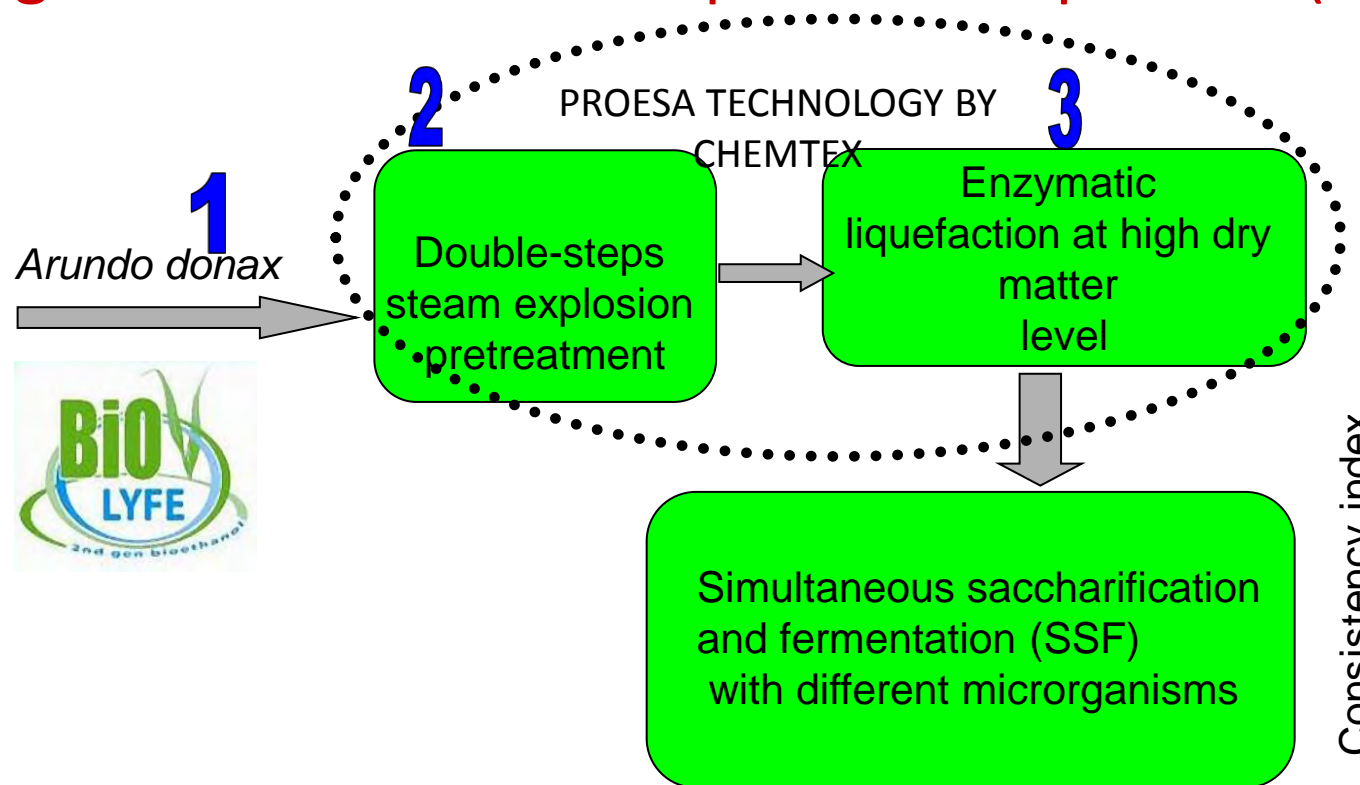
*Source: ENEA CR TRISAIA*

The scope of the pretreatment is high biomass destructuration+high C5 recovery

- 1.mild thermal conditions along with small amounts of acid catalysts (i.e. SO<sub>2</sub>, H<sub>2</sub>SO<sub>4</sub>)
- 2.Chemtex process , two steps process: hemicellulose is separated before steam explosion

# THE BIOLYFE PROJECT

The BIOLYFE project aims at improving critical steps of the second generation bioethanol production process ([www.biolyfe.eu](http://www.biolyfe.eu))



ENEA source: *Arundo donax* fiber (CTX), S/L 30%  
pH 5; T 50°C, CTEC2 17 FPU/g DM

# CHEMTEX: BIOFUEL DRIVEN DEMO PLANT



More than ...

- 400 days of operation
- 3000 hours of operation
- 10 kinds of biomass tested

Multiple enzymes and MO's tested

## Largest in the World Cellulosic Ethanol Plant

- 40 ktpa nameplate  
(60 ktpa design)
- 15 MWe green power
- Start up 2012
- Using wheat straw and arundo donax

# PLANT FEEDING

**FEEDSTOCK** (around 170.000 tons of dry biomass per year)

1. Fibre Sorghum
2. Miscanthus grass (*Miscanthus x giganteus* hybrid),
3. Giant Reed (*Arundo donax*),
4. Switchgrass (*Panicum virgatum*).

## BASIN OF BIOMASS

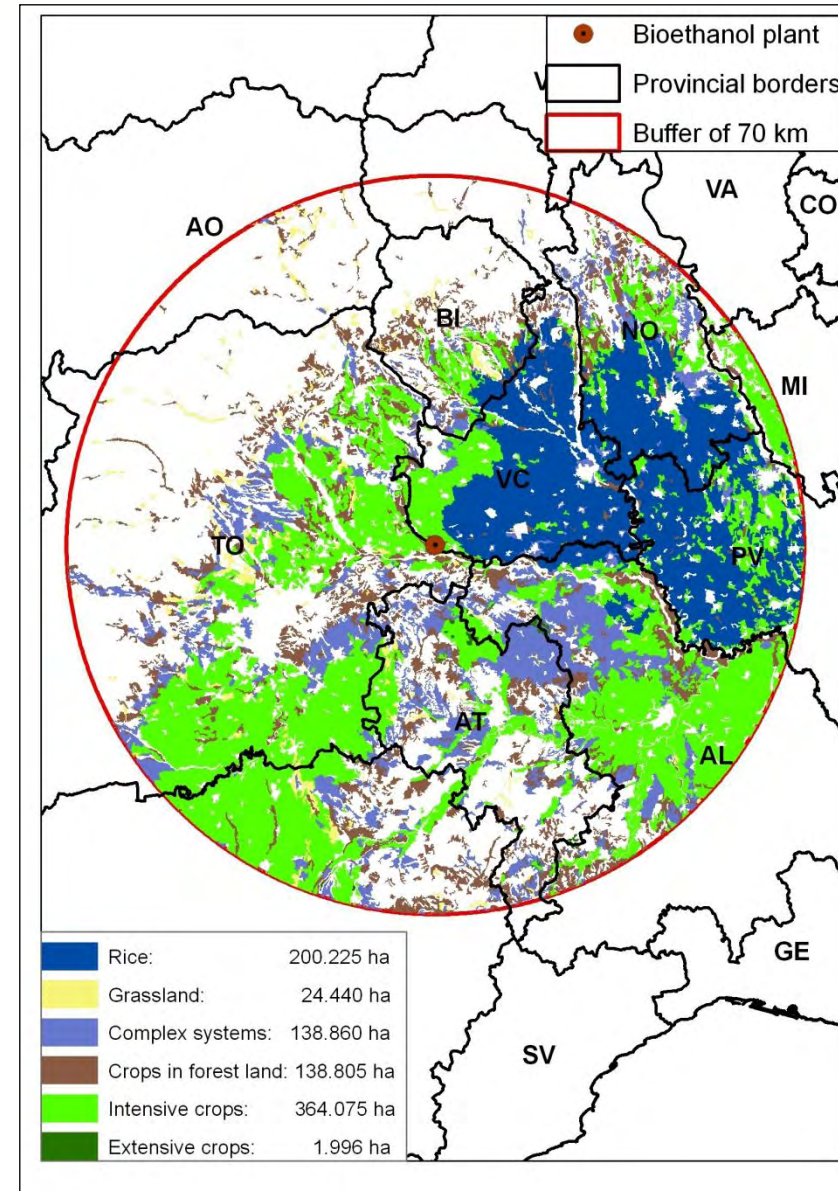
A radius of 70 km around the production plant for biomass sourcing.

## OPPORTUNITIES

Diversification of local crops with other crops (i.e. energy crops for ethanol production) could be an attractive option for grain producers in the region and might also become an option for rice producing farmers

Less than 2.5 % of the grain cultivation area for energy crop production would be necessary.

Arundo should provide a gross profit margin of EUR 300-400 per hectare



SOURCE: BIOLYFE NEWSLETTER

# Beta Renewables: Profile and Business Model



1. **Until the end of July, around 600,000 L of 2 G bioethanol were produced and sold in Europe.**

2. **Beta Renewables has licensed the technology in Brazil and Malaysia**



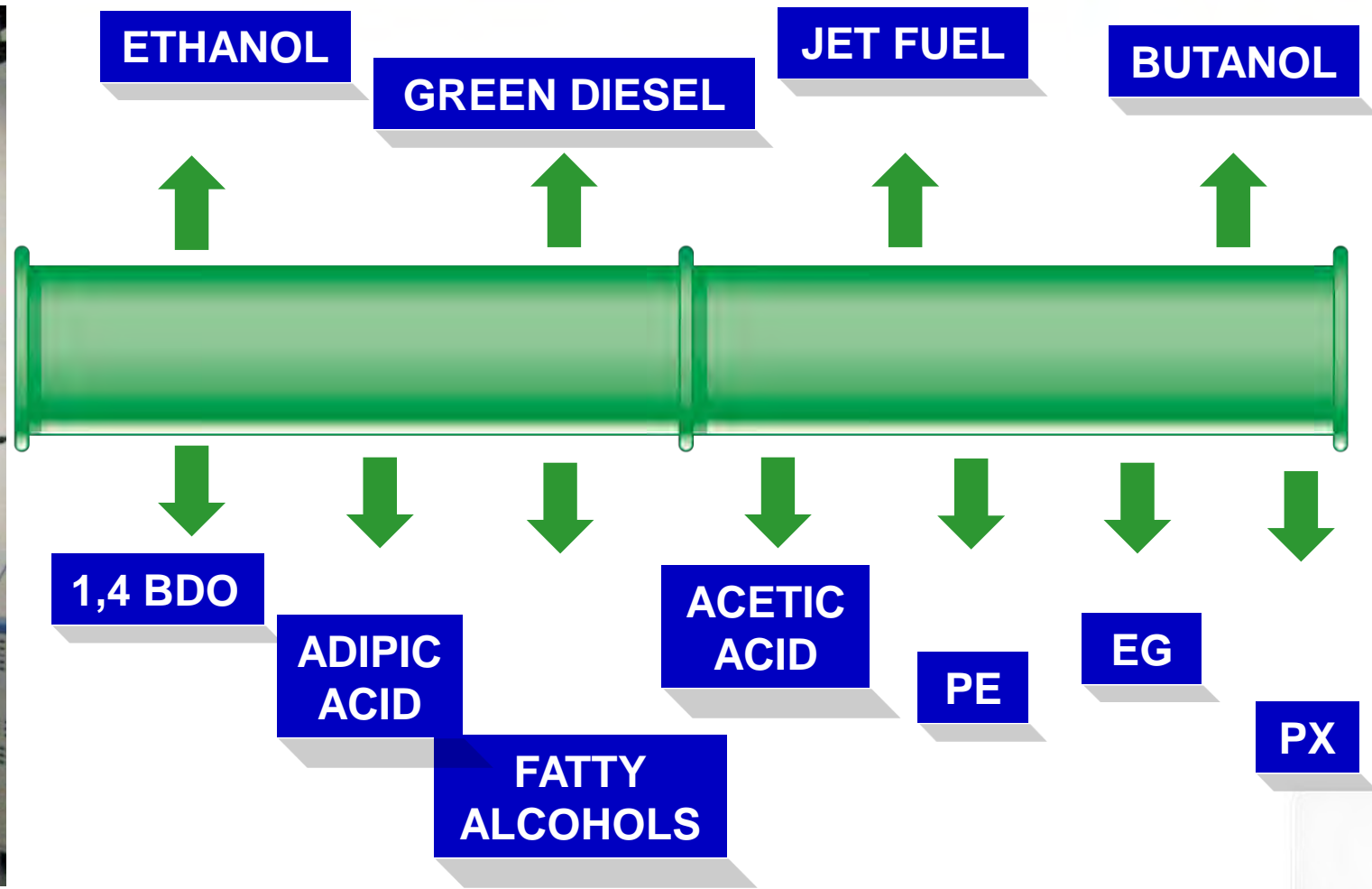
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To Jointly Market PROESA® and CTEC3®

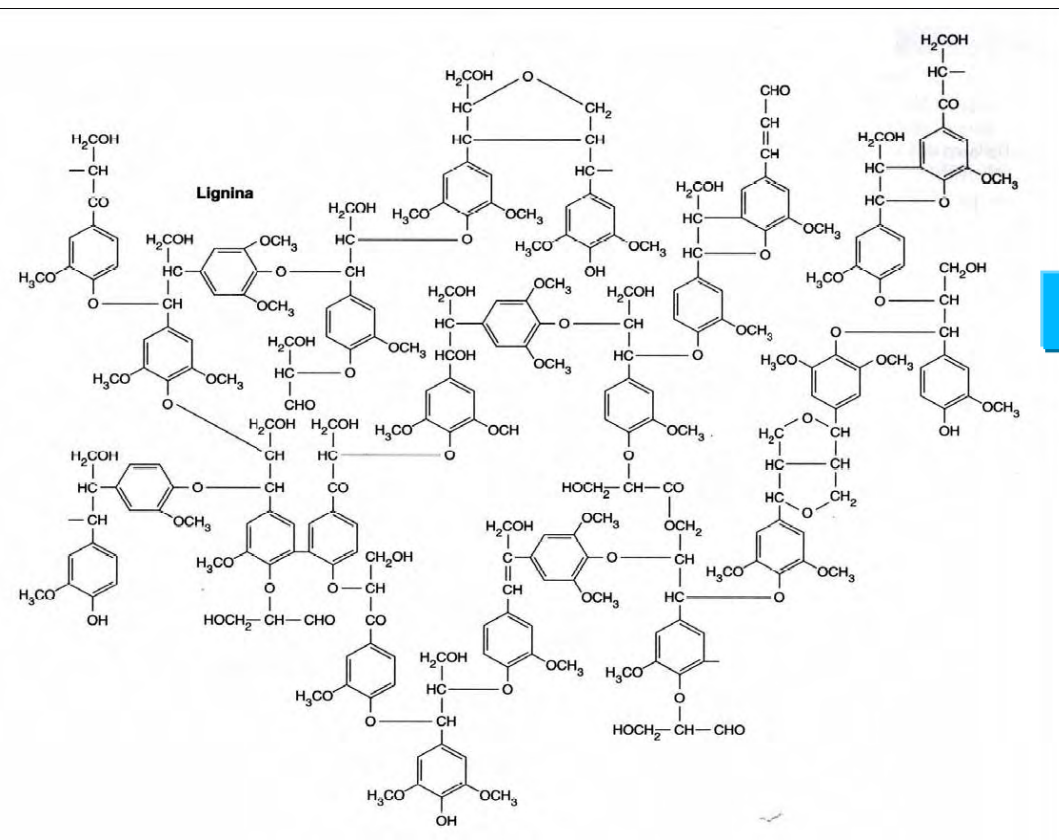
- ✓ Beta renewables was funded in 2011
- ✓ In 2012 a partnership was created between Novozymes and Beta renewables .
- ✓ Long-standing collaboration has led to substantial reduction in cost of enzymes per unit of cellulosic ethanol
- ✓ Partnership of two industry leaders boosts confidence in the technology
- ✓ Guarantees on enzyme performance and cost incidence
- ✓ Parties are committed to ongoing improvements in enzymes and process
- ✓ Ensuring secure and most competitive enzyme supply to the customers

# HOW TO EXPLOIT PROESA® Technology

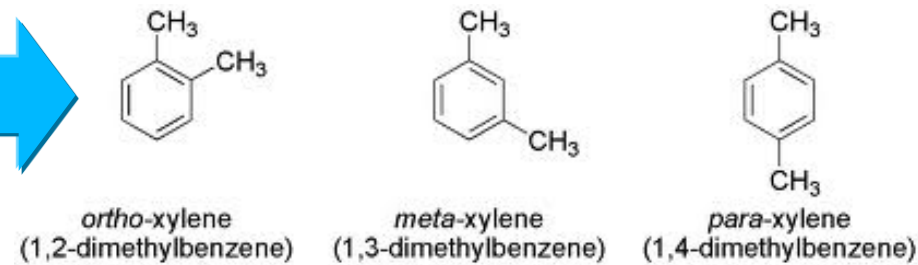


## THE BIOMASS SUGAR PLATFORM

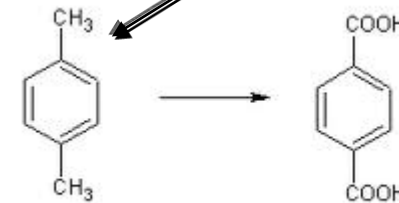
# NEW TECHNOLOGY FOR THE PRODUCTION OF XYLENES



LIGNIN



Potential application?



Terephthalic acid → PET

The MOGHI technology (CHEMTEX) has been tested in US at the continuous pilot scale. A new plant is going to be built in southern Italy, near Bari with a capacity of 1 kton/y of bioreformate.

# How does a commercial-scale plant look like ?

✓ Commercial-scale  
20MMgpy cellulosic ethanol  
plant in Crescentino, Italy  
operational in 2012

✓ Cellulosic Costs  
Estimated cash costs:  
Ethanol: <\$1.50/USG      Sugars: 10¢/lb



Pretreatment



Distillation



Fermentation

Viscosity  
Reduction

Official opening  
8 October 2013



# BIO-PRODUCTS DRIVEN BIOREFINERIES FROM NOVAMONT-TERNI



Leader in the European bioplastics industry

Mater-Bi, the trademark, is a **starch-based biodegrade** material.

Investments of 31 M€ were made. The plastics bags can be composted and returned to the soil once the product's lifecycle is completed.

Production in 2008 was 80 kt/y



**The process :**  
destruction of the starch proteins, amorphous amylase and amylopectine, which are then complexed with polyester through hydrogen bonding.

## MATERBIOTECH (NOVAMONT)



- ❑ New fermentation plant in the site of a previous plant (Adria ) for the production of Butandiol (BDO) from renewables
- ❑ Important partnership with Genomatica.
- ❑ Start-up 2014
- ❑ Plant size: 20.000 ton/y



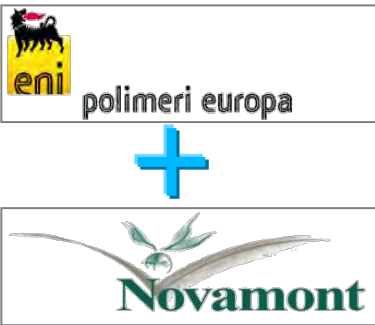
# BIOBASED PRODUCTS

INTEGRATED BIOREFINERIES : FROM FEEDSTOCK TO THE FINAL BIOBASED PRODUCTS

## Biorefinery in Porto Torres



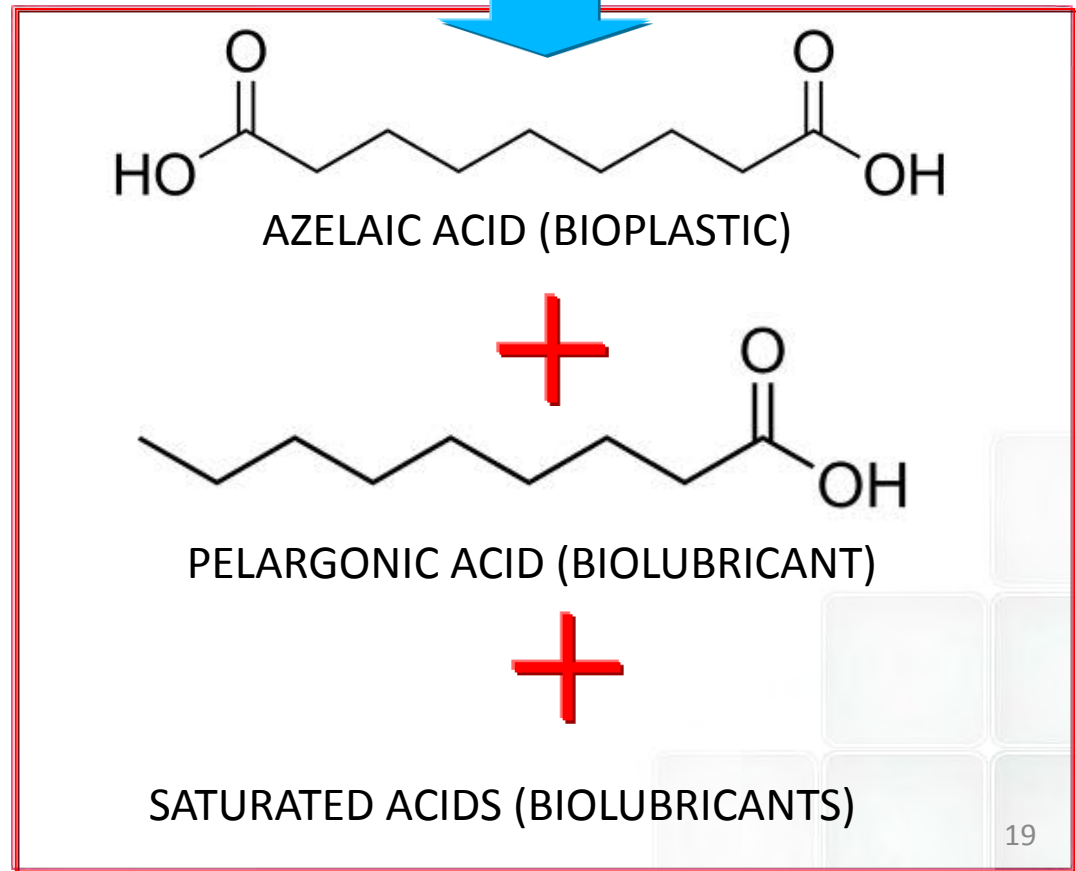
Feedstock: cardoon



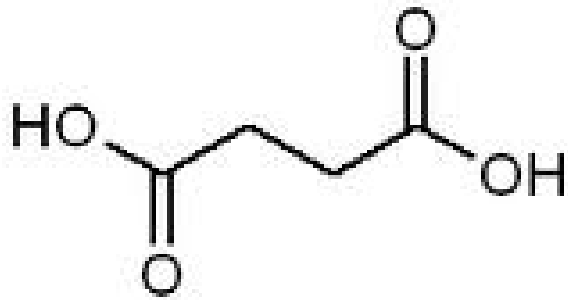
**MATRICA**  
 Joint venture for  
 a biorefinery in  
 Porto Torres  
 (Sardinia)

7 plants with a total investment of 500 M€

**BIOBASED PRODUCTS:**  
 monomers (38 kton/y),  
 rubber additives, bio-  
 fillers, biolubrificants (29  
 kton/y), bio-plastics



# Production of bio-succinic acid



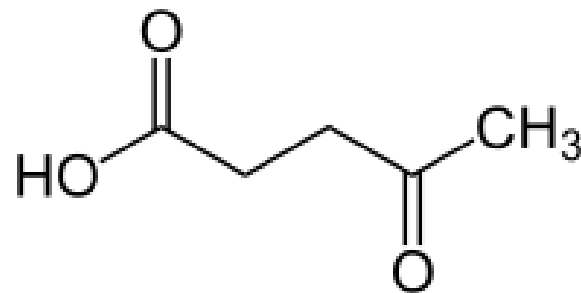
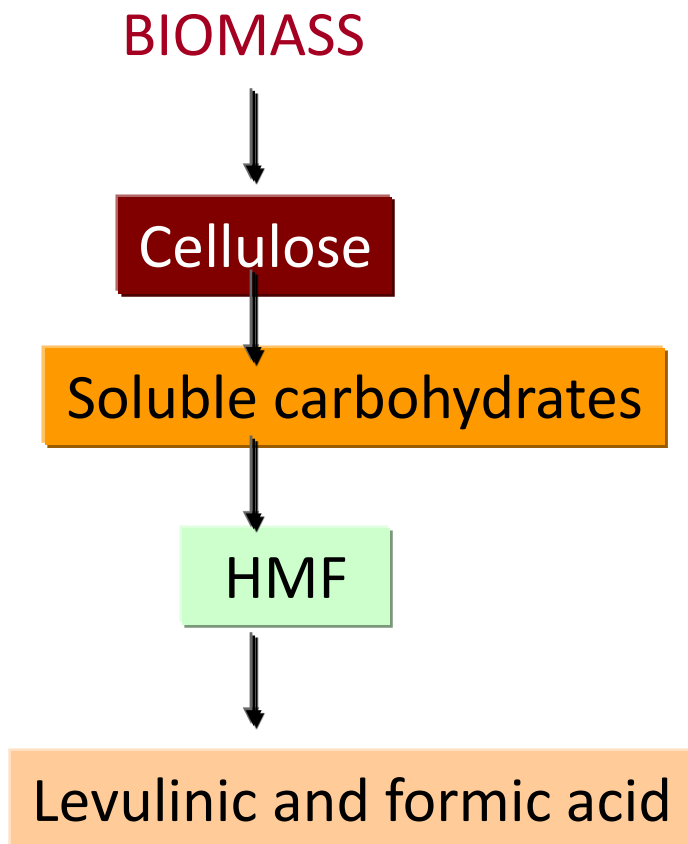
**Succinic acid**



**Reverdia, the joint venture between DSM and Roquette Freres.**

World's first bio-succinic acid plant (10 kton/y) through a yeast-based fermentation process in Cassano Spinola (Italy)

# PRODUCTION OF LEVULINIC ACID (“Le calorie SpA” Caserta)



The process is based on the acid catalyzed hydrolysis and dehydration of sugars. The continuous process is based on a patent developed by Biofine Inc. (Massachusetts- USA)

# NATIONAL PROGRAMS ON BIOREFINERIES: ITALIAN CLUSTER FOR THE GREEN CHEMISTRY



## what

- Proposal of joint research projects in the field of green chemistry
- submitted to the Italian Ministry of Education, University and Research in September 2012, with the scope of aggregating the main stakeholders and ensuring coherence between regional, national and EU programmes.

## why

- In line with the EC orientations to promote the Italian biobased industries

## who

- **Promoters:** Novamont S.p.A., Versalis S.p.A., Chemtex Italia S.p.A., Federchimica
- **109 public and private entities** in the field of Bioeconomy
- Involvement of the **Italian major public research organizations** in the field of biomass collection and transformation: CRA, CNR, **ENEA**
- Support of **8 Italian Regions**

# “GREEN CHEMISTRY” CLUSTER: *KEY CONCEPTS*



Biorefineries for the production of added value products (i.e. biochemicals and bioplastics)

Reconversion of industrial sites facing severe crisis

Use renewable raw materials including residues or dedicated sustainable crops

Establishment of public-private partnership in order to accelerate the industrialization of innovative technologies

## **PROJECTS LEADERS:**

- 1. VERSALIS**
- 2. NOVAMONT**
- 3. MATERBIOTECH**
- 4. CHEMTEX**

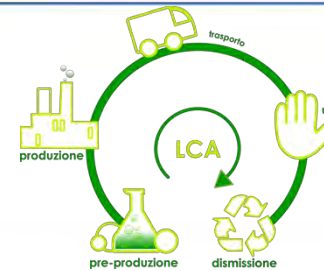
4 initial R&D and demo projects, coordinated by the promoters companies



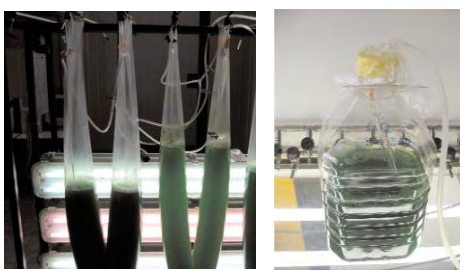
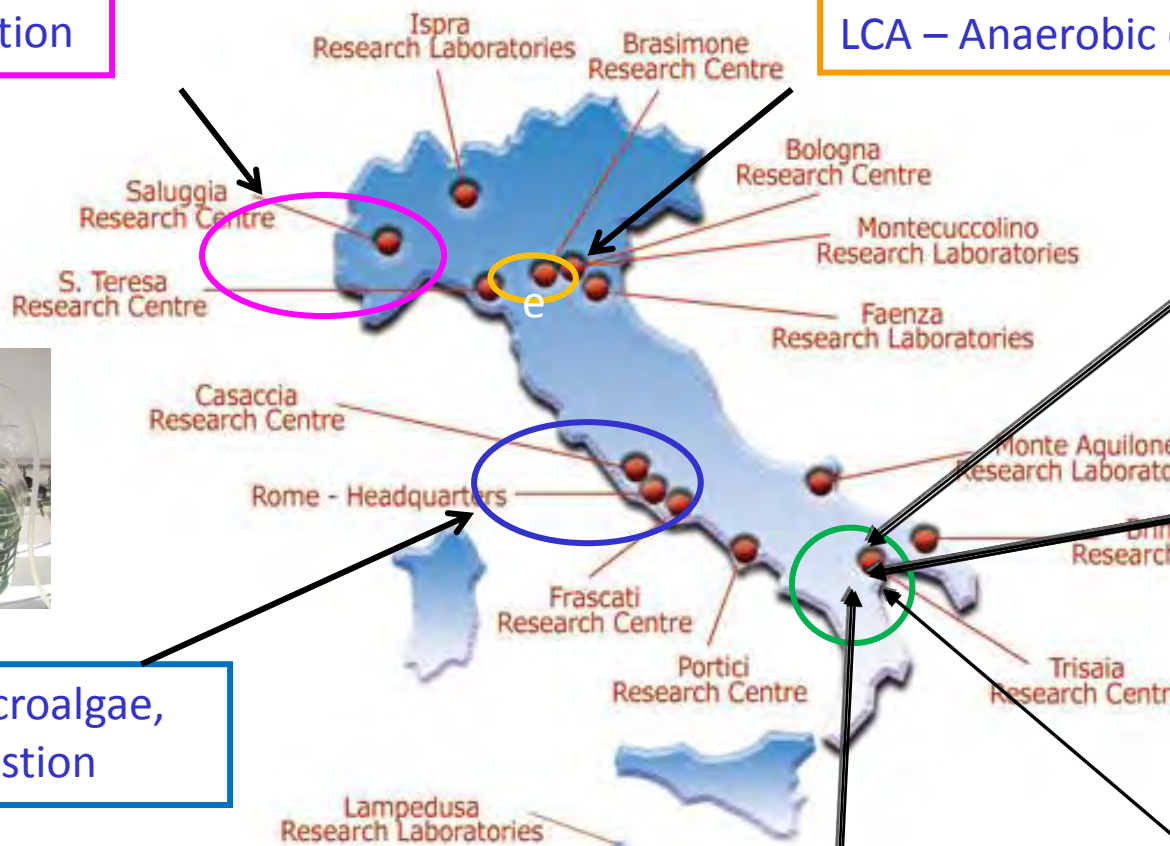
# ENEA'S RESEARCH CENTRES WITH ACTIVITIES IN THE BIOENERGY/Biorefinery SECTOR



Biomass combustion



LCA – Anaerobic digestion



Biodiesel from microalgae, anaerobic digestion

**ENEA TRISIAIA**  
Energy crops, thermochemical processes, biomass pretreatment and fractionation, biotechnological processes



# Concluding remarks

## NEW CHALLENGES OF THE RESEARCH IN BIOREFINING

Capitalization of the knowledge developed in the sector of biofuels for the maximum exploitation of the “biomass barrel”.

Unlike petroleum, the most biomass are solids with 40% oxygen-→the development of “biomass tailored technologies” and processes is necessary

## DEVELOPMENT OF TOOLS TO COMPARE DIFFERENT BIOREFINING OPTIONS FOR THE SUSTAINABILITY ASSESSMENT

A number of different pathways for the use of bioresources are available  
Interaction or competition with each other within the bioenergy market?

# CONCLUDING REMARKS



## NON TECHNICAL CHALLENGES

- Clear and encouraging policies about advanced biofuels and use of biomass/residues/energy crops. are necessary (mandates for advanced biofuels within the 10% target, incentives, tax exemptions, easy procedures adapted to this kind of sustainable plants, agricultural policies etc)
- Huge investments from chemical companies and banks
- A higher cooperation with the petrochemical value chain (i.e blending of biofuels, distribution ) and the automotive suppliers (i.e. making available vehicles for ethanol blended fuels)

## • BIOREFINERIES SUSTAINABILITY

Food and ghg reductions are both key factors for our planet future. The promotion of an efficient use of land is desirable, aiming at a COMPLEMENTARY production of food and sustainable energy (i.e. biomass grown on marginal, unused, polluted lands).

**THANKS FOR YOUR  
ATTENTION**

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