ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES, ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT

Biorefineries and green chemistry: Italian country report

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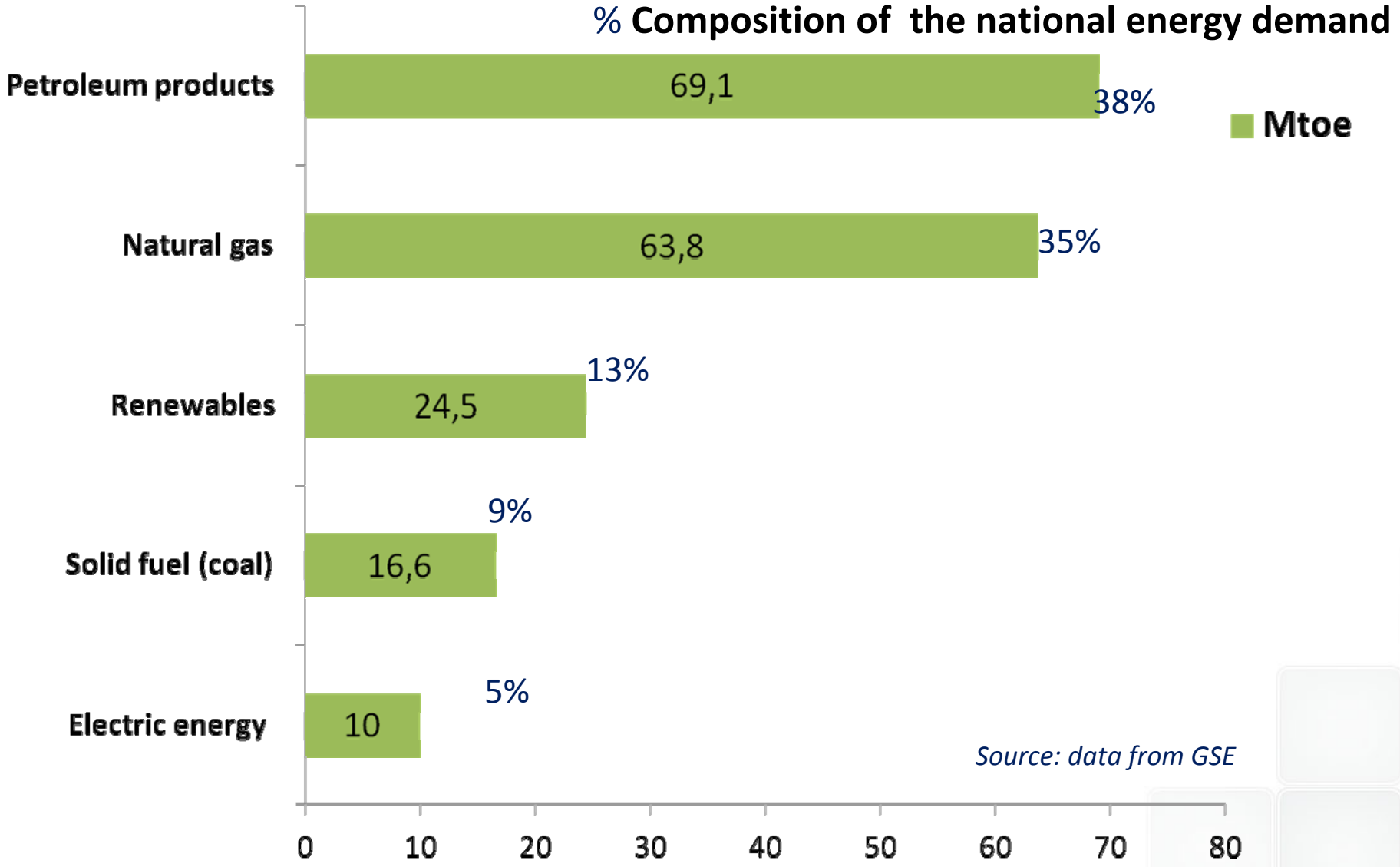
ITALY – NATIONAL ENERGY DEMAND IN 2011

Total energy demand in 2011: 184 Mtoe



Source: data from GSE

ITALIAN ACTIONS PLAN FOR THE RENEWABLE ENERGIES/BIOMASS AND BIOENERGIES

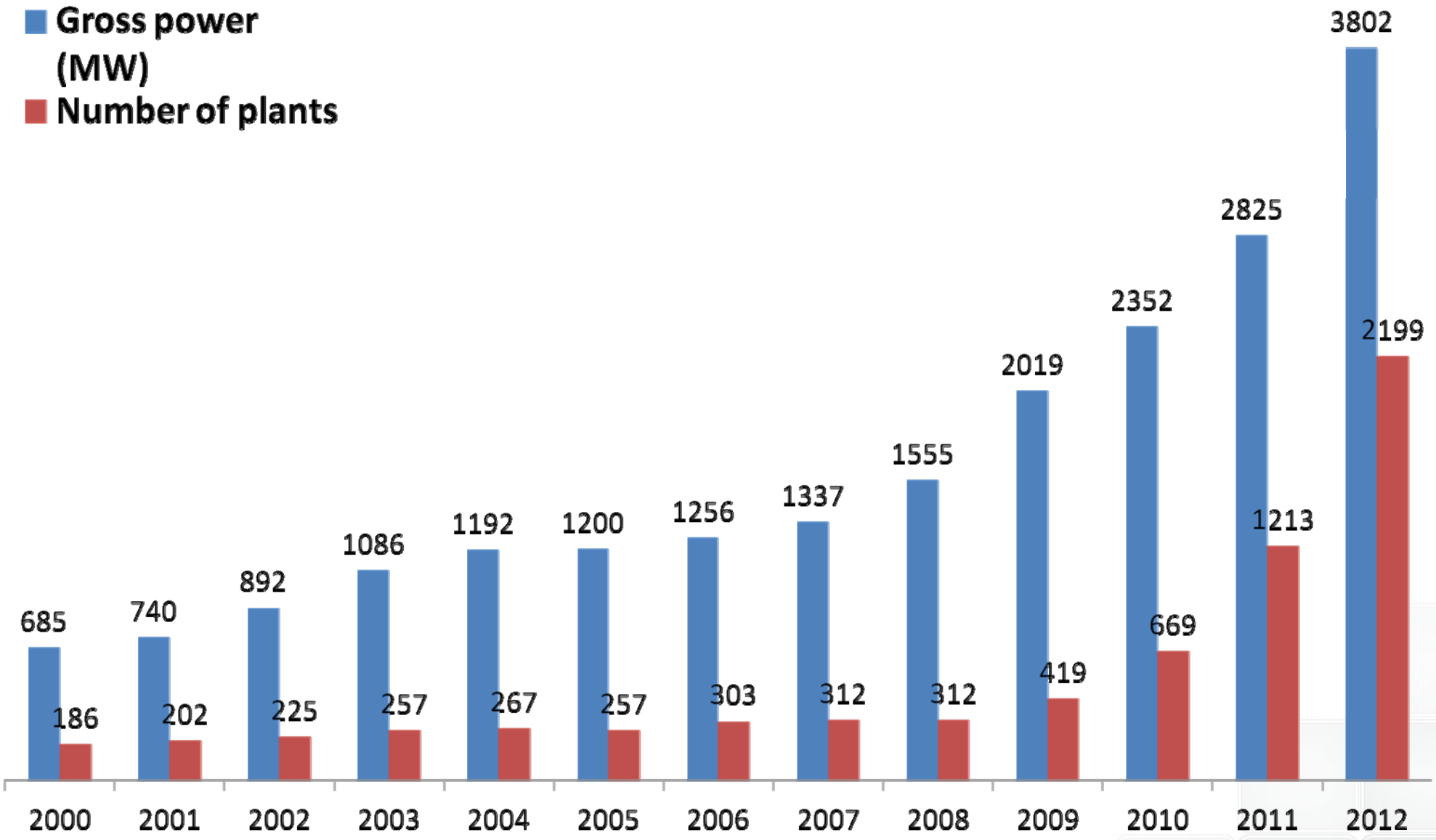
2005	2011		2020
0.4 Mtoe	0.9 Mtoe	Electricity →	1.8 Mtoe
1.65 Mtoe	4.4 Mtoe	Thermal energy →	5.5 Mtoe
0.2 Mtoe	1.4 Mtoe	Biofuels →	2.5 Mtoe
2.25 Mtoe	6.7 Mtoe	TOTAL bioenergy	9.8 Mtoe

Second generation biofuels will count double with respect to the energetic value

6.94 Mtoe	14.5 Mtoe (2011)	22.3 Mtoe

TOTAL renewables for 17% substitution at 2020

PRODUCTION OF ELECTRIC ENERGY FROM BIORESOURCES IN ITALY



Data from GSE

BIOMASS POTENTIAL IN ITALY AND AVAILABLE BIOMASS (energy in PJ)

	SOURCES					
	[10]	[40]	[38]	[39]	[41]	[42]
Forestry	*167*	*38*	*180*	*247*	*121*	*544*
direct wood	167	38	138	176	100	448
indirect wood	0	0	38	71	21	96
Agriculture	*272*	*406*	*502*	*611*	*285*	*234*
crops	67	406	373	188	13	4
by-products	205	0	130	423	272	230
Waste	*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
Total	**540**	**469**	**783**	**1055**	**553**	**846**

Source:
Renewable Energy 57 (2013) 448-461

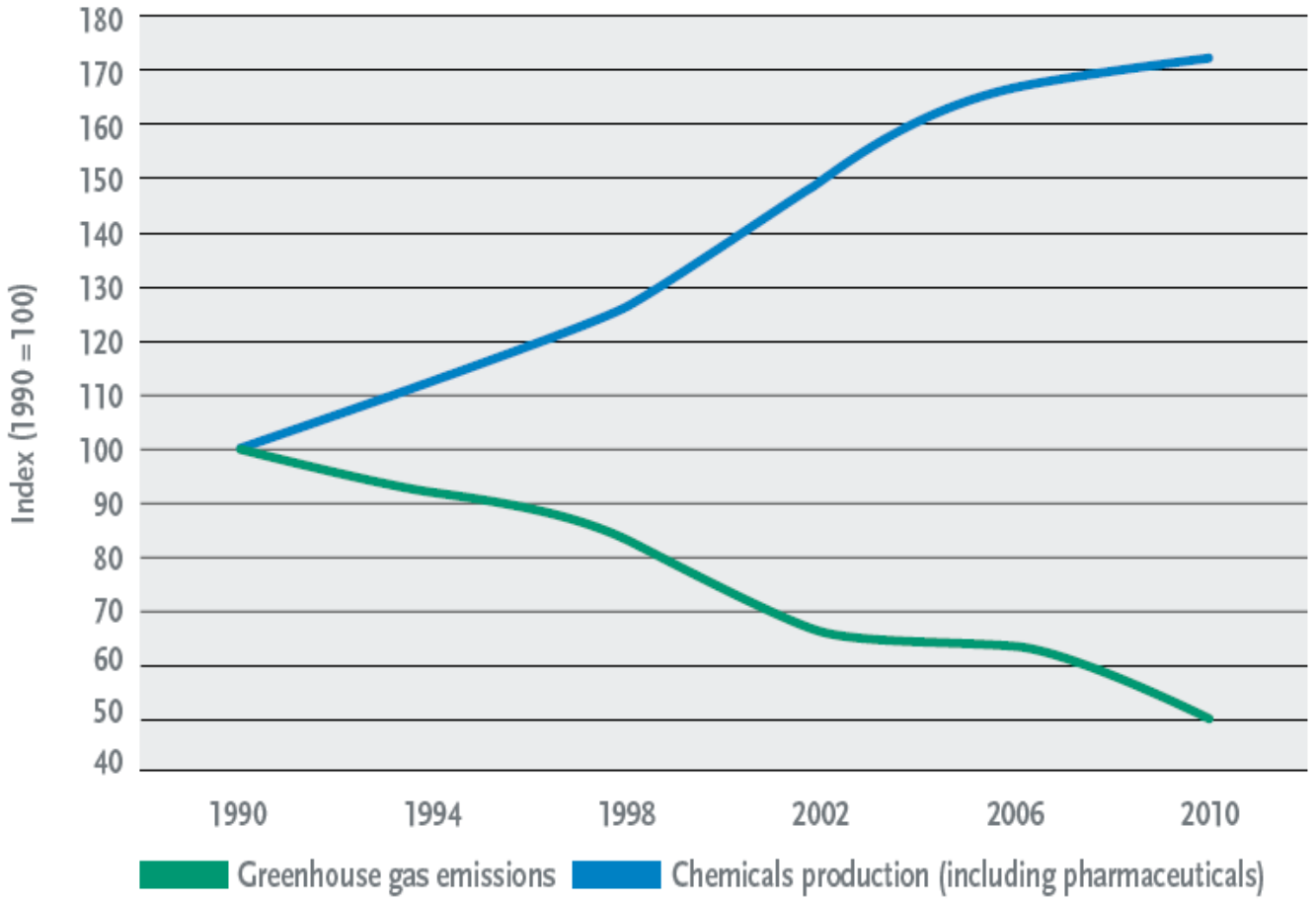
National Renewable Energy Action Plans, 2011

Data from the ENEA's ITALIAN BIOMASS ATALS

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

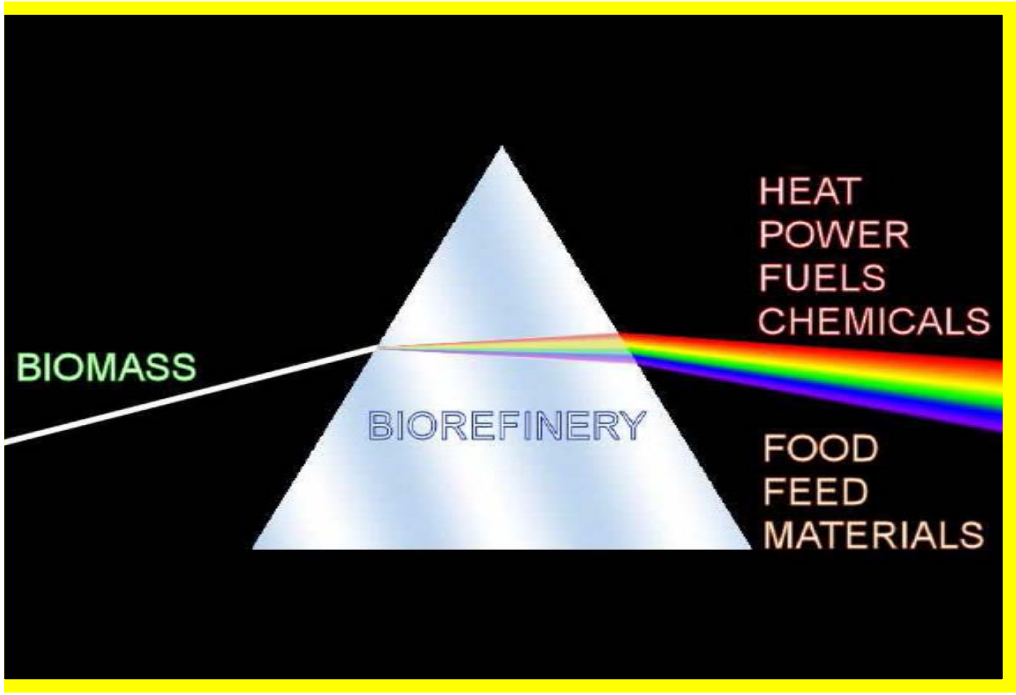
NEW PERSPECTIVES FOR THE CHEMICAL INDUSTRY FROM THE "GREEN" ECONOMY

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

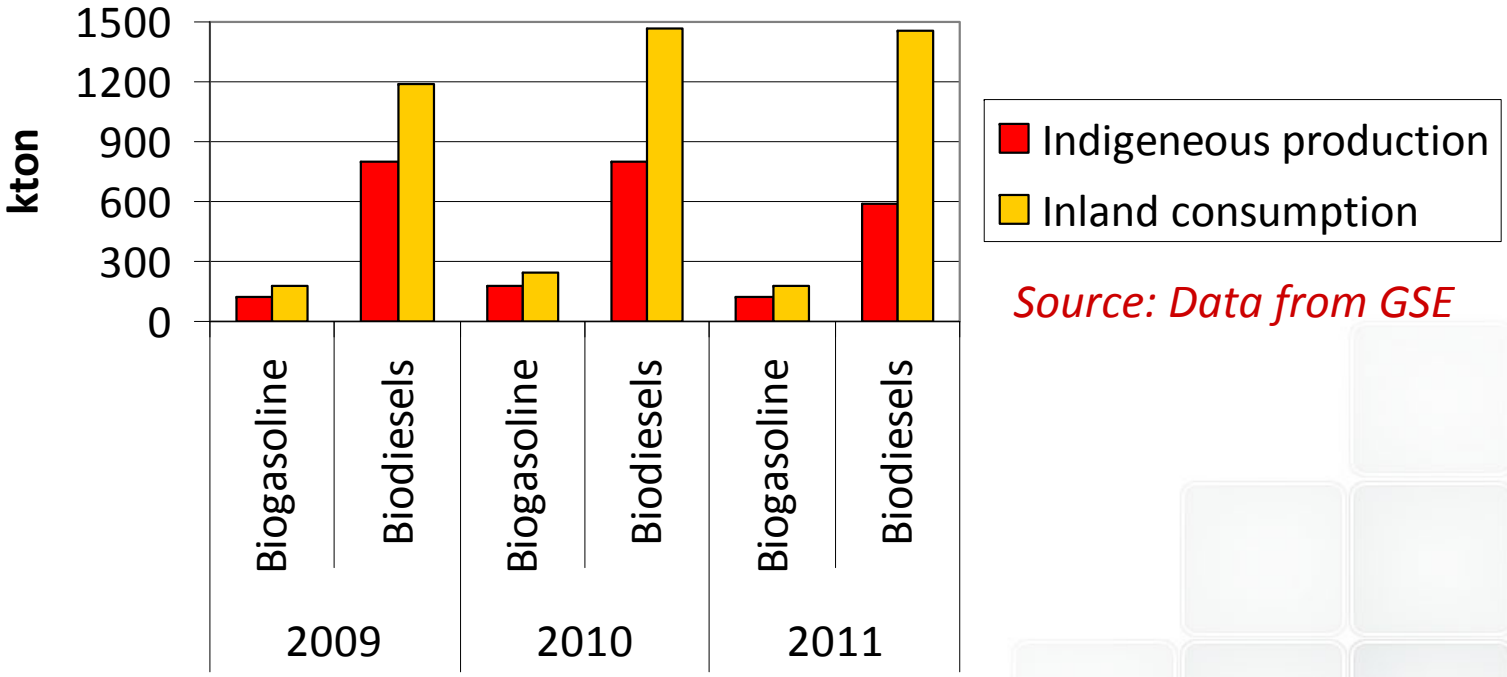
PRODUCT DRIVEN
green-chemicals, materials (bioplastics) →
- •Biolubricants
- •Biosuccinic acid
- •bioplastics
- •Levulinic acid
- •Additional Carboxilic acids

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.



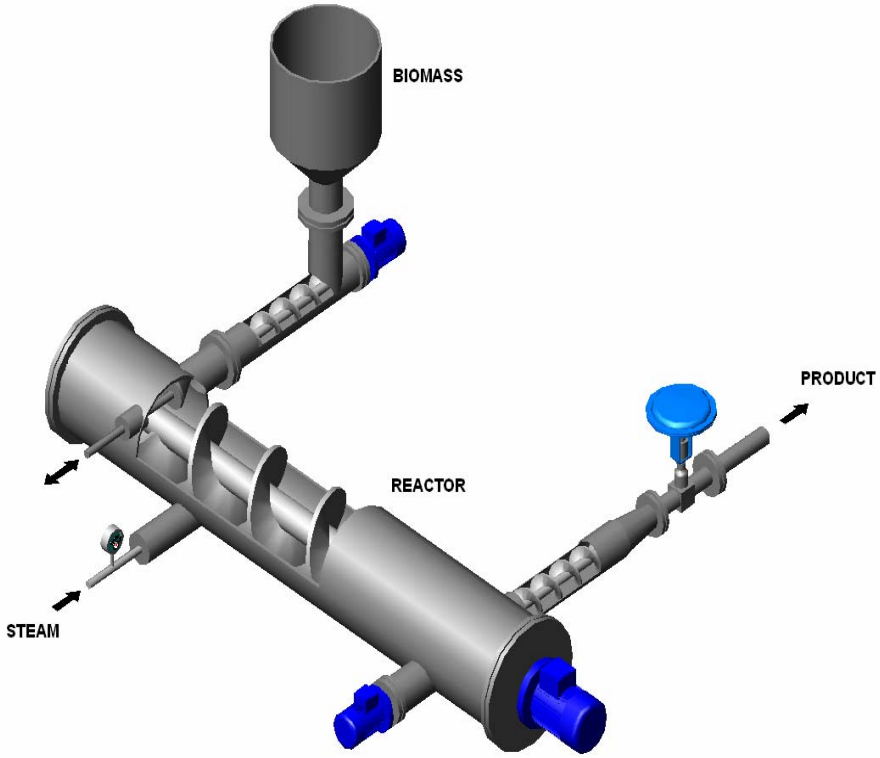
Source: Data from GSE

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 TRSAIA IN ITALY (300 kg/h)



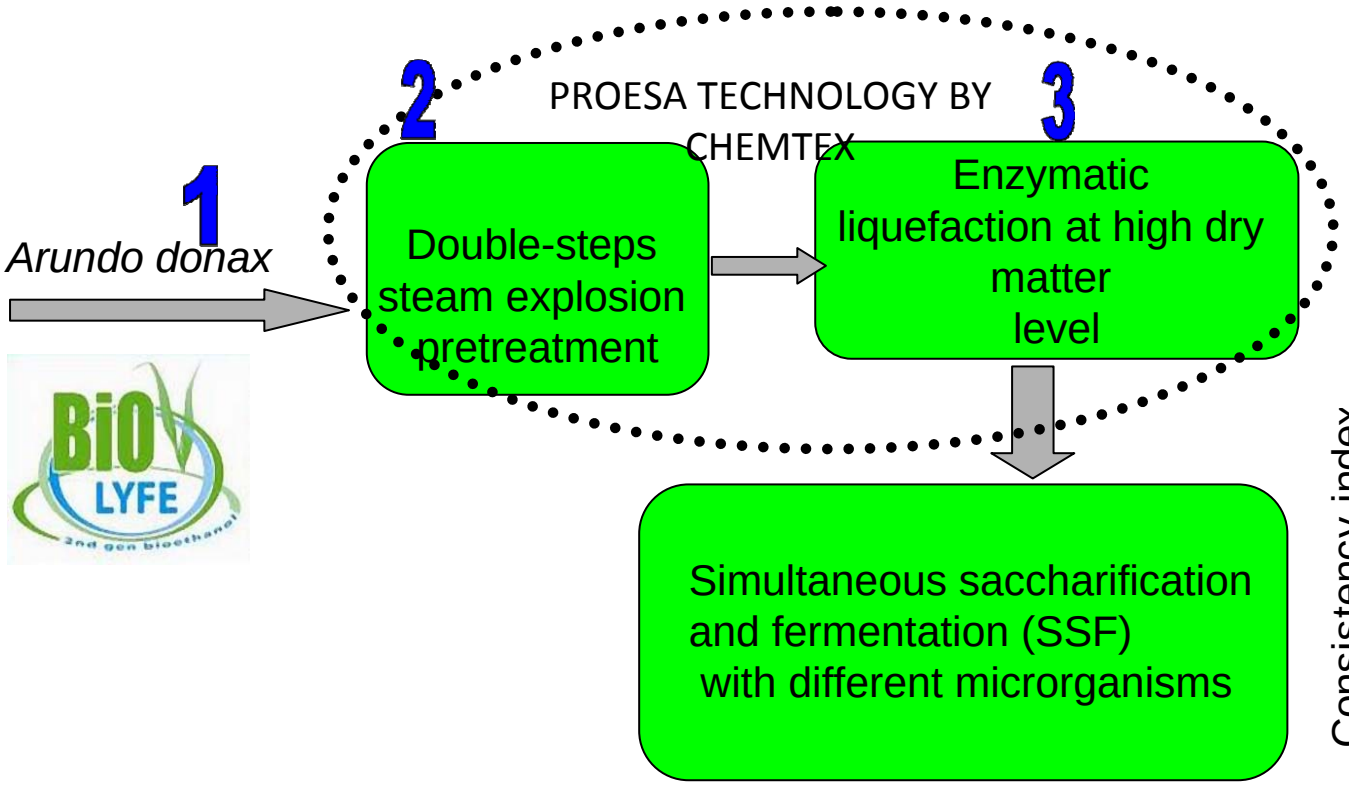
Source: ENEA CR TRISAIA

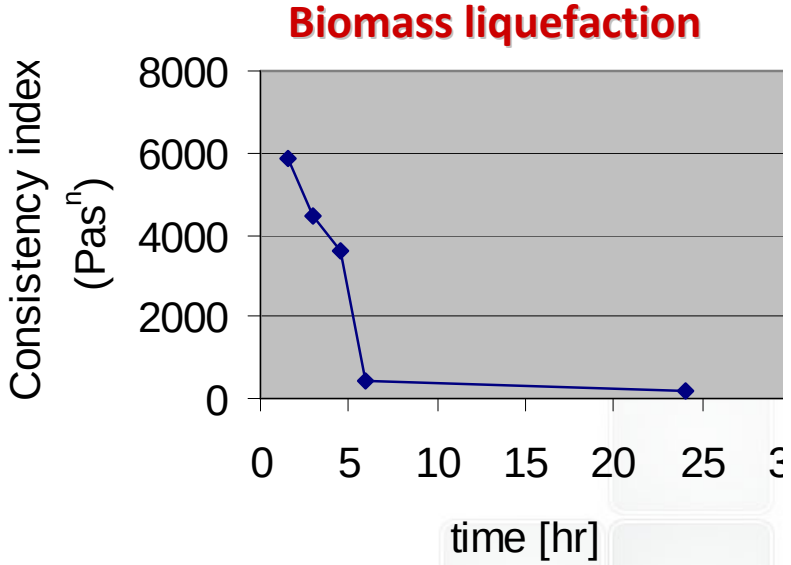
The scope of the pretreatment is high biomass destructuration+high C5 recovery

1.mild thermal conditions along with small amounts of acid catalysts (i.e. SO2, H2SO4)
2.BioChemtex process , two steps process: hemicellulose is separated before the destructuring, steam assisted, step

THE BIOLYFE PROJECT

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





ENEA source: Arundo donax fiber (CTX), S/L 30%

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**

Source: Biochemtex

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

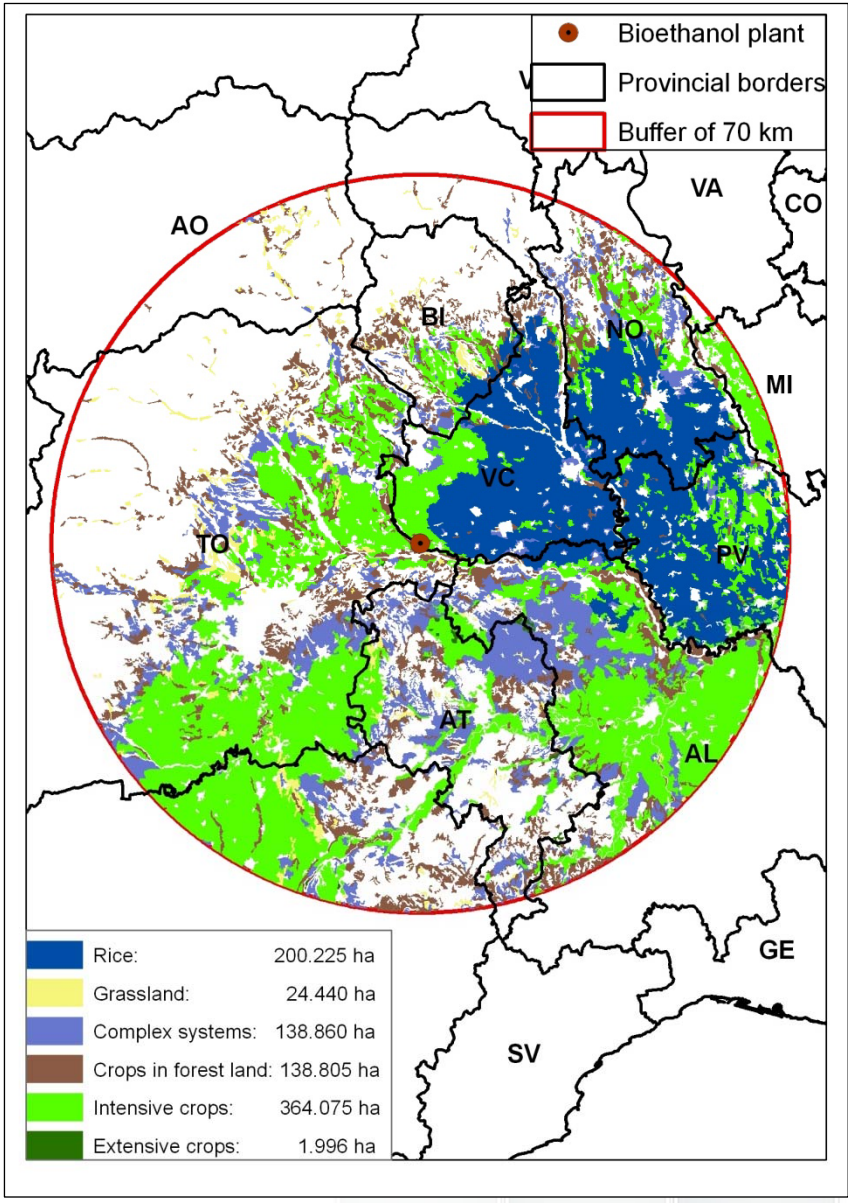
A radius of 70 km around the production plant for biomass sourcing.

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

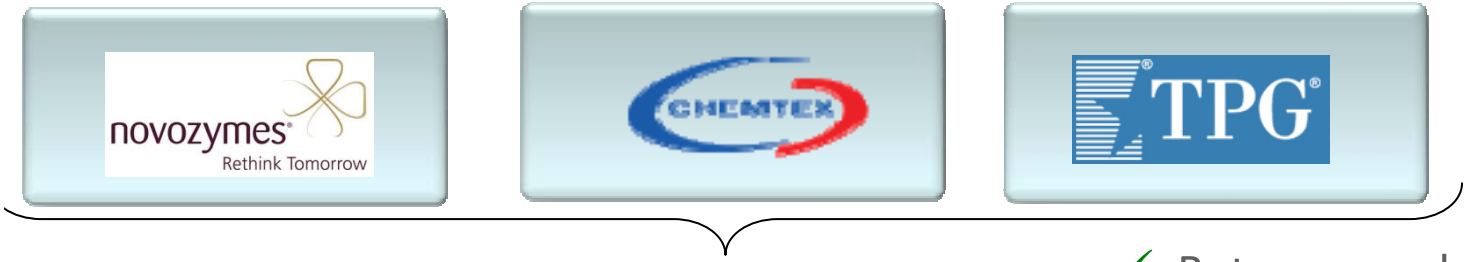
<u>Less than 2.5 % of the grain cultivation area for energy crop production would be necessary.</u>

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 2013, around 600,000 L of 2 G bioethanol were produced and sold in Europe.**

BETA RENEWABLES S.p.A.

+

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

novozymes
Rethink Tomorrow

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

Source: Biochemtex

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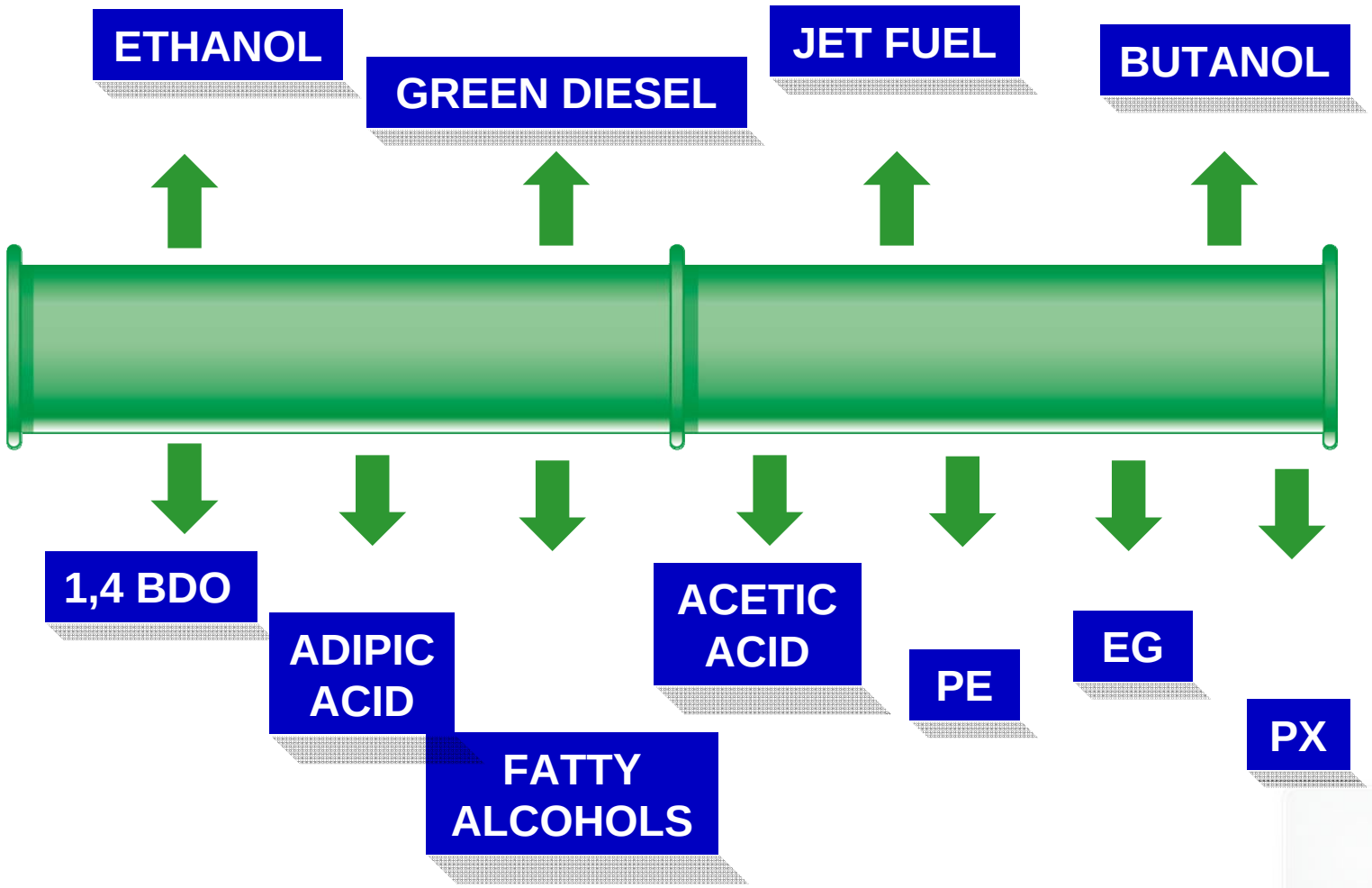
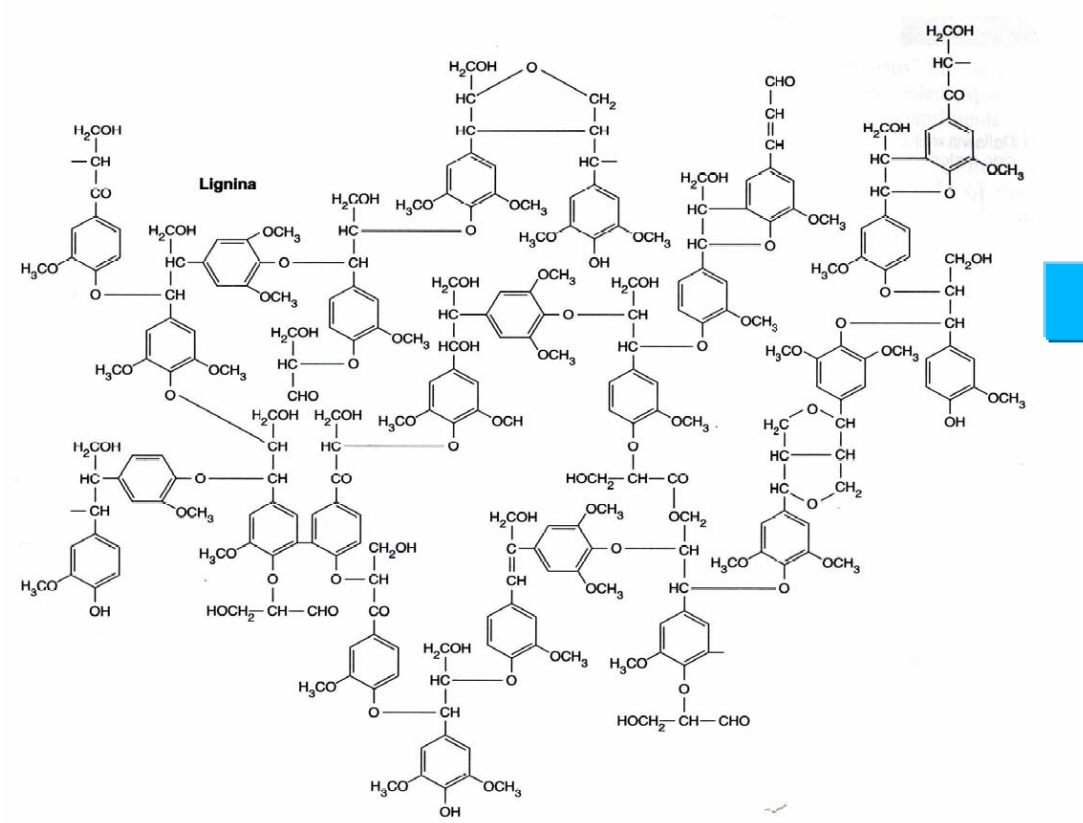
HOW TO EXPLOIT PROESA® Technology



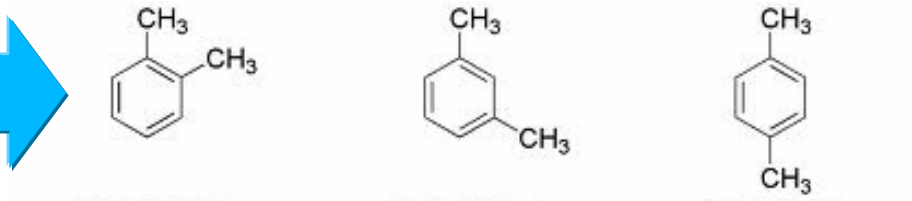
THE BIOMASS SUGAR PLATFORM

Source: Biochemtex

NEW TECHNOLOGY FOR THE PRODUCTION OF XYLENES



LIGNIN

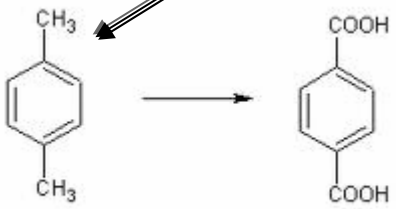


ortho-xylene (1,2-dimethylbenzene)

meta-xylene (1,3-dimethylbenzene)

para-xylene (1,4-dimethylbenzene)

Potential application?



Tereftalic 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

Viscosity Reduction

Official opening 8 October 2013

Fermentation

Distillation

SOURCE: BIOCHEMTEX

BIO-PRODUCTS DRIVEN BIOREFINERIES FROM NOVAMONT-TERNI

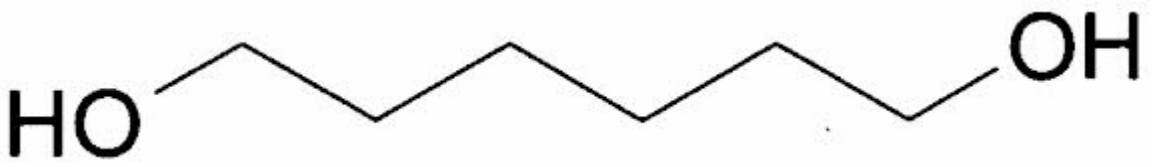
Leader in the European bioplastics industry

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

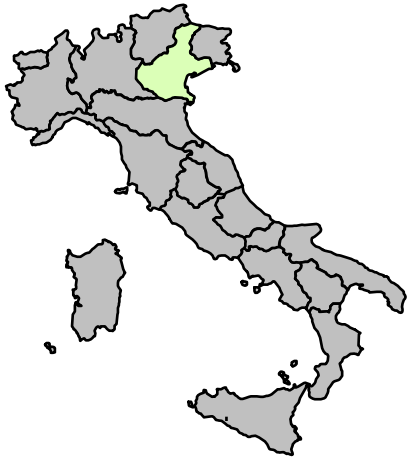
The process :
destructuration of the starch proteins, amorphous amylase and amylopectine, which are then complexed with polyester through hydrogen bonding.

PRODUCTION OF BDO

MATERBIOTECH (NOVAMONT)



BDO



- 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

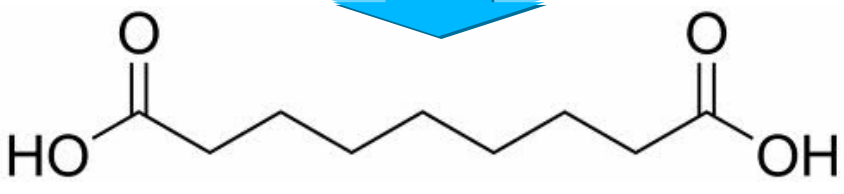
SEEDS → Vegetable oils

eni polimeri europa + Novamont

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



AZELAIC ACID (BIOPLASTIC)

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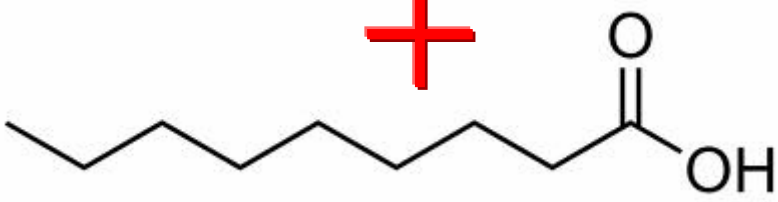

PELARGONIC ACID (BIOLUBRICANT)

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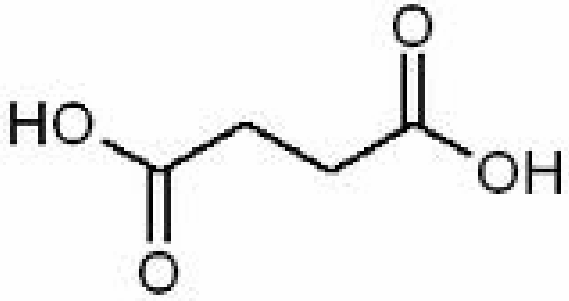
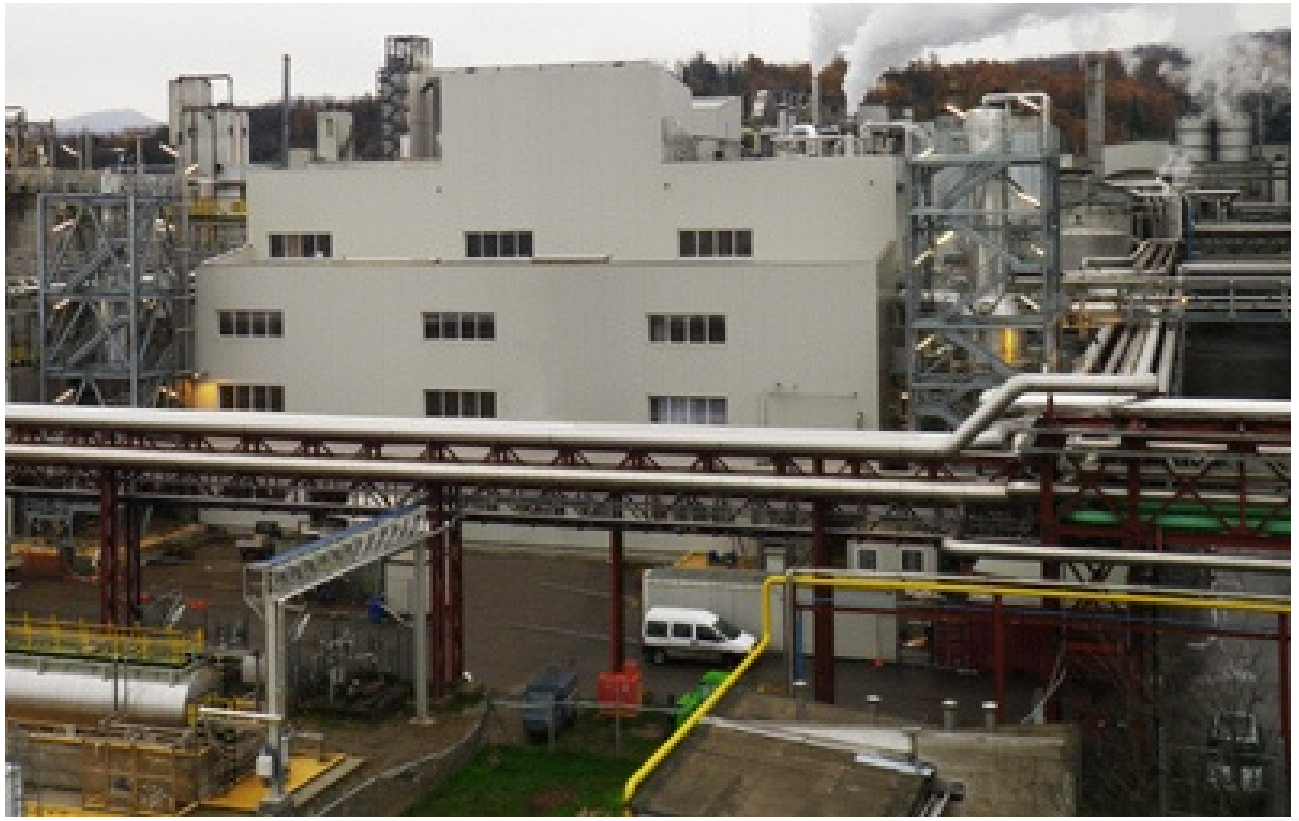
SATURATED ACIDS (BIOLUBRICANTS)

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)

BIOMASS

↓

Cellulose

↓

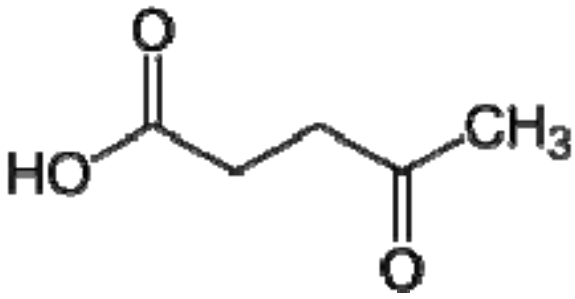
Soluble carbohydrates

↓

HMF

↓

Levulinic and formic acid



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. (Massachussetts- 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*

Source: Novamont presentation by Catia Bastioli

"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

Source: Novamont presentation by Catia Bastioli

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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