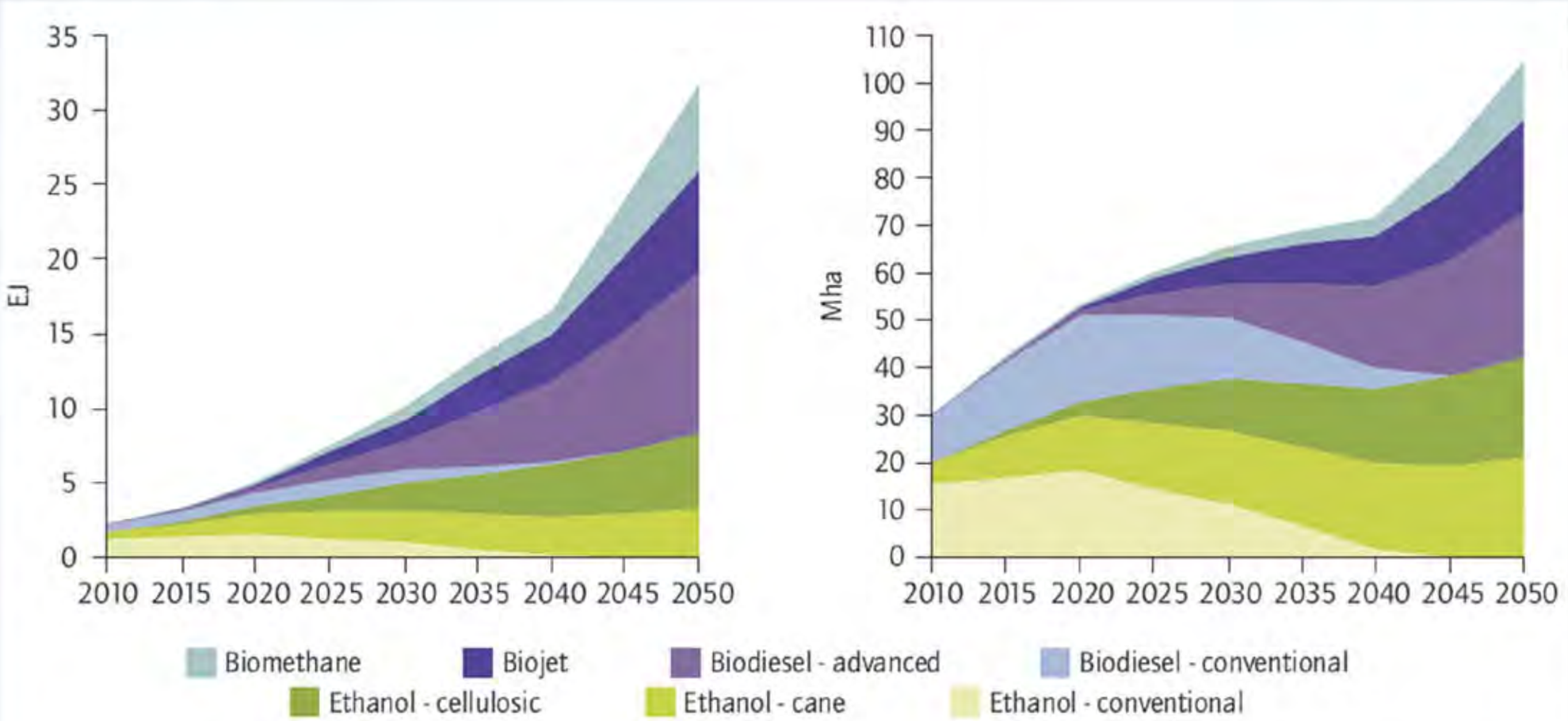
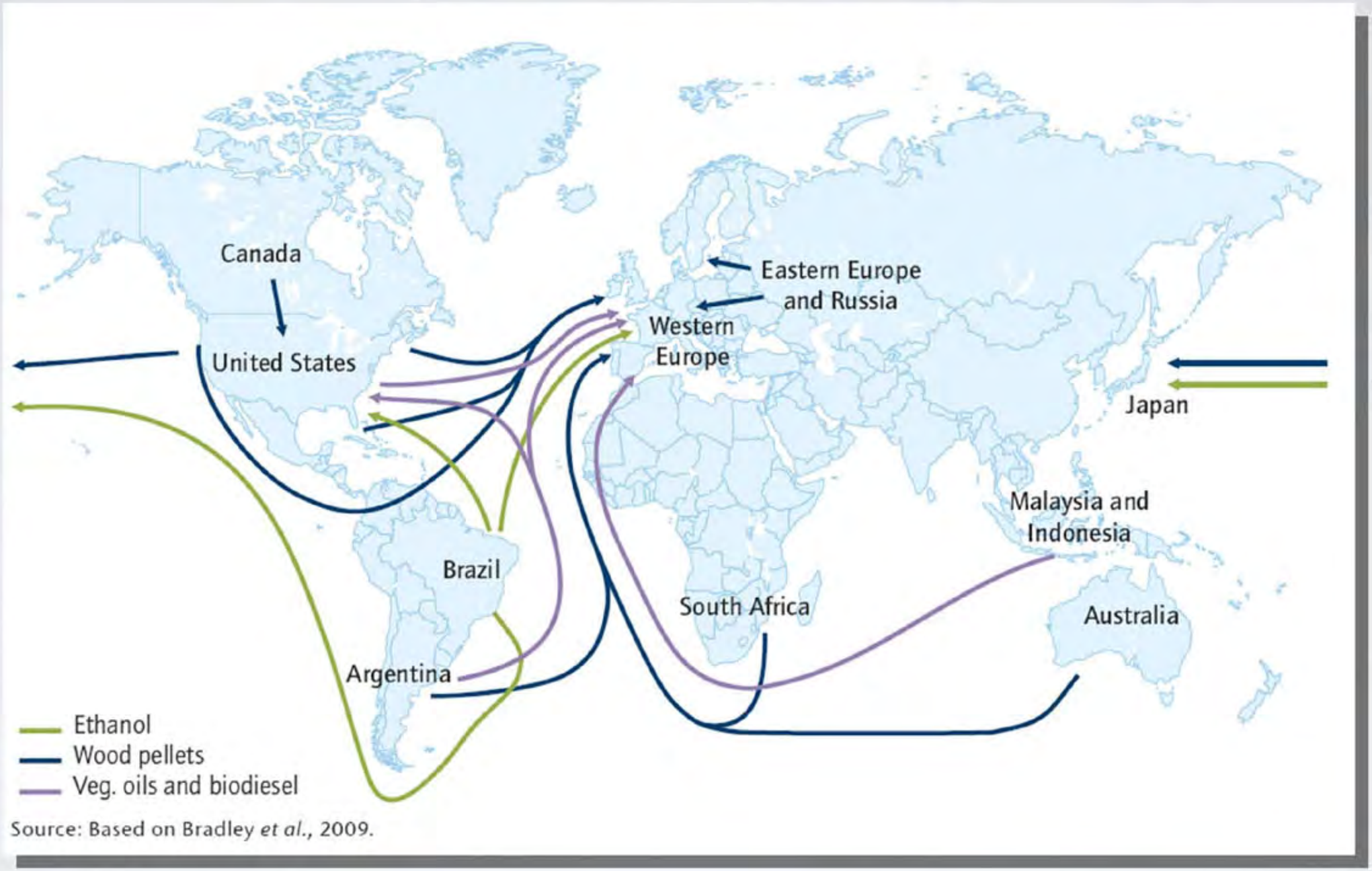
Demand for biofuels (left) and resulting land demand (right) in this roadmap



Note: This is gross land demand excluding land-use reduction potential of biofuel co-products. This assumes 50% of advanced biofuels and biomethane are produced from wastes and residues, requiring 1 Gt of residue biomass. If more residues were used, land demand could be reduced significantly.

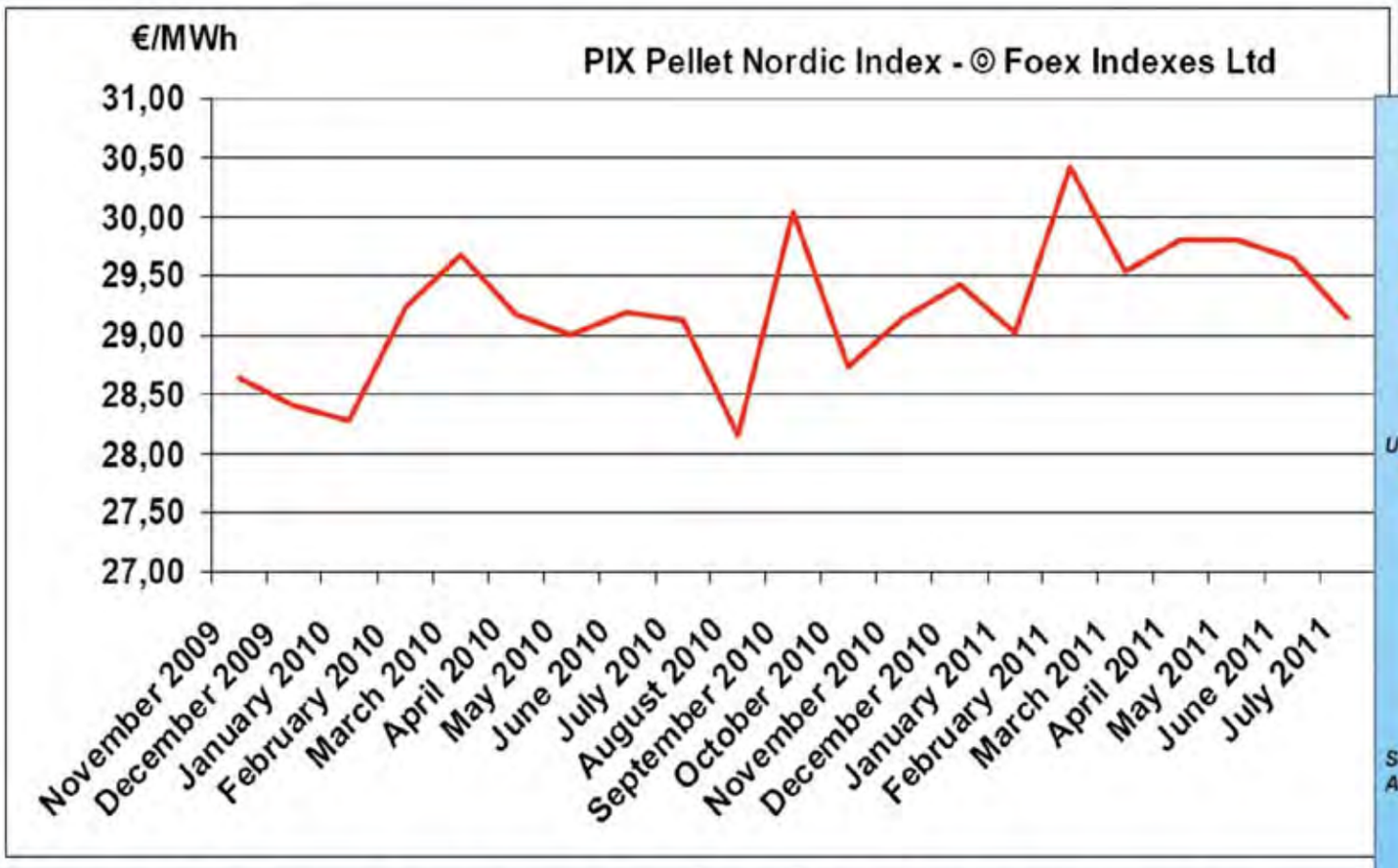
Source: IEA analysis based on IEA, 2010c and Table 2 below.

World biomass shipping today



Source: Based on Bradley *et al.*, 2009.

Industrial wood pellet



....market ready....

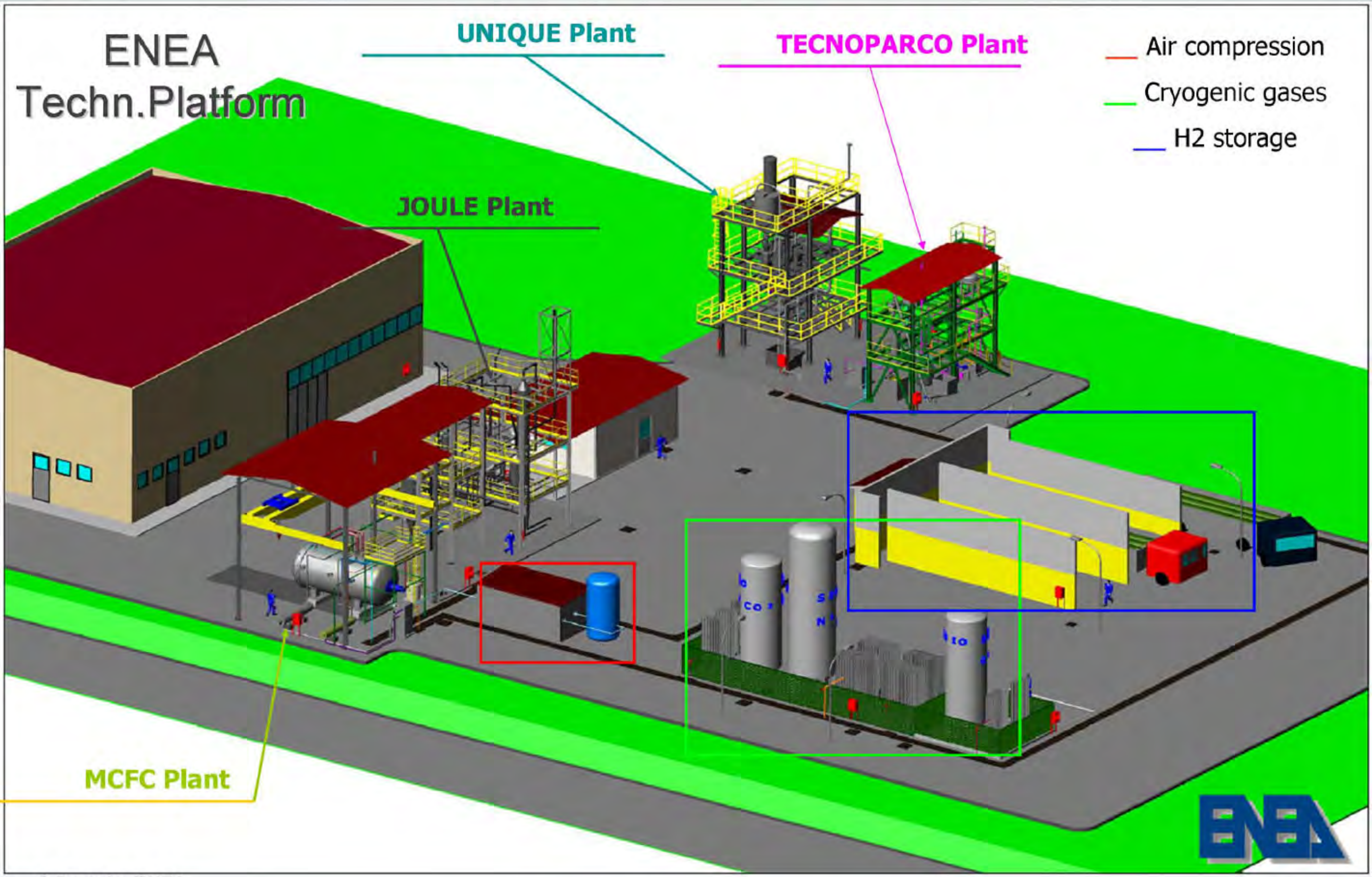
- ✓ Solid biomass potential 157 Mtoe, 48% already exploited
- ✓ A large share of bioenergy in Europe originates from by-products and residues from the forest industry, both from mechanical and chemical processing, that are not suitable for further processing for other products.
- ✓ A large amount of forest growth is not used, and an estimated annual increment of wood stock is over 300 million solid m^3.
- ✓ EUBIONET III: Price index for industrial wood pellets developed in cooperation with Foex Indexes

VTT

SYNTHETIC BIOFUELS

David Chiaramonti

ENEA Techn.Platform



G.Braccio, ENEA, 2011

C.R.E.A.R. CENTRO RICERCA ENERGIE ALTERNATIVE E RINNOVABILI

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Università degli Studi di Firenze

ENEA Technological Platform for biomass gasification

G.Braccio, ENEA, 2011

David Chiaramonti

BTL

- Several R&D projects on the BTL path
- Demo not yet available
- Downstream processes sensitive to feedstock characteristics

LIGNOCELLULOSIC ETHANOL

- Global presence : 11 plants in the world (5 in Brazil, 4 in Italy, 1 in Mexico and 1 in USA)
- Turnover : about 2.1 billion $ in 2009
- 3 Business Units: PET Polymer, Acetates , Engineering
- Staff: 2600 persons on 6 location (Italy, Brazil, India, China, USA, Mexico)
- 3 R&D Centers: Italy, USA and Brazil

Mossi & Ghisolfi Group

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

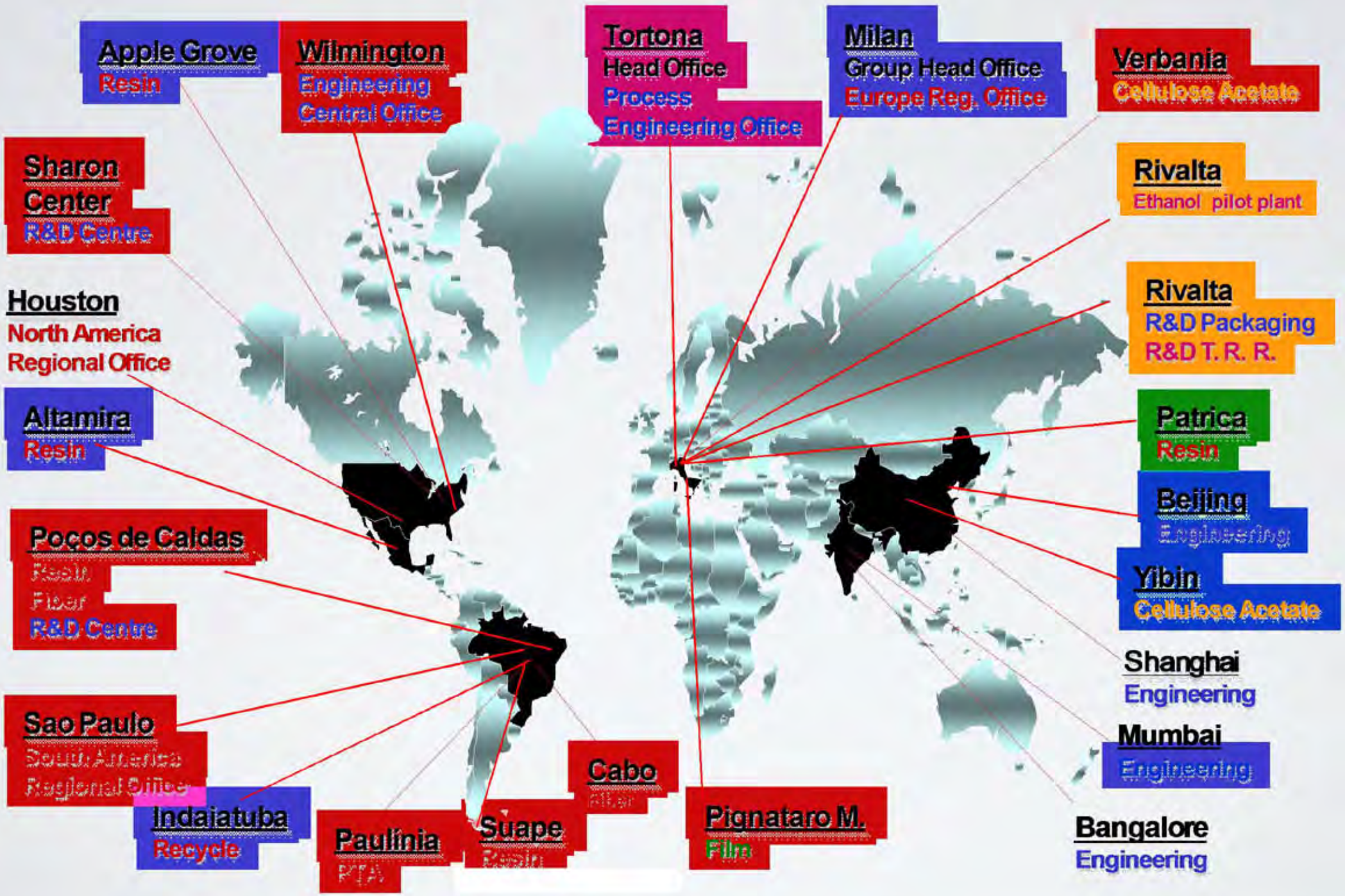
Acquisition of Shell's PET business

Acquisition of Brazilian controlled Rhodia-Ster from Rhodia Poliamida

Start-up of world's largest PET production unit at Altamira (Mexico)

Acquisition of the world class engineering group Chemtex from Mitsubishi Corporation

M&G Overview: Sites



PRO.E.SA™: Steps

Break-through technology for the production of Bio-fuels and Bio-Chemicals from Cellulosic Biomass

Chemtex Italia R&D Center

3000m² labs dedicated to Renewable Resources, >45 people dedicated to R&D

2007 - 2008

Scouting, testing and development of technology on lab scale

2009 - 2010

Construction and tests on a continuous pilot plant

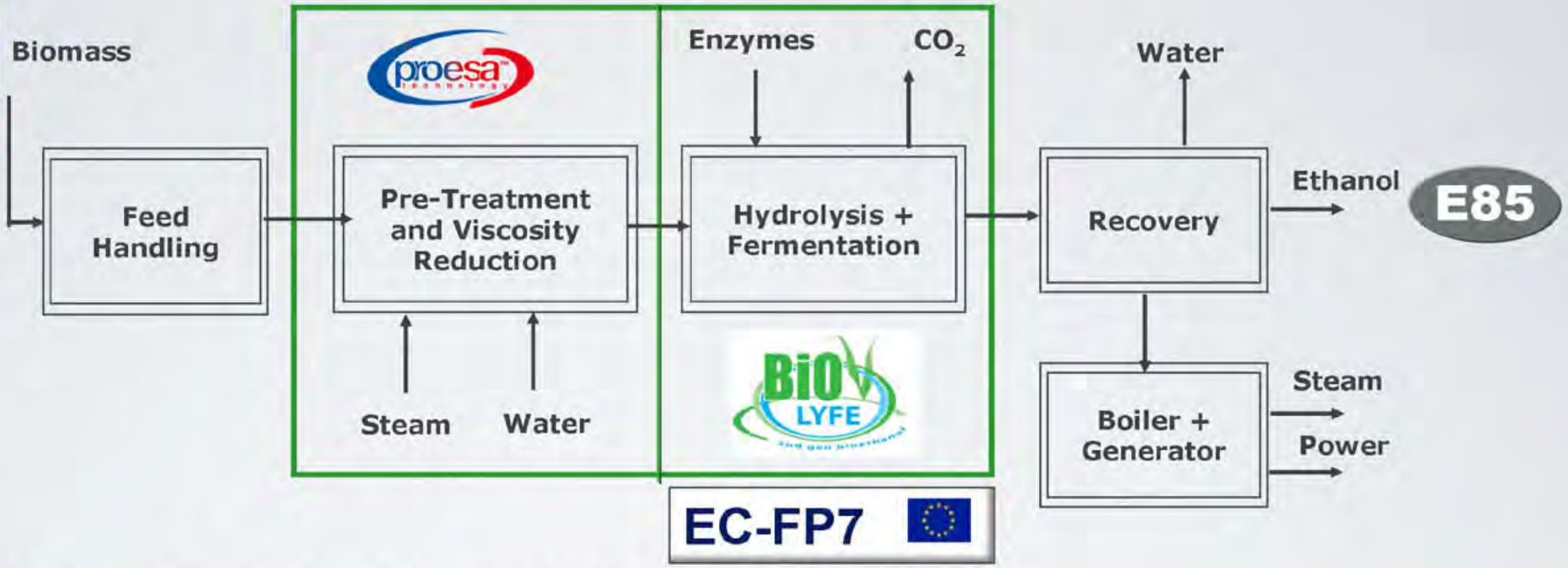
2011

Construction of a Demonstration Plant

40 ktpa (15 MGY)

Technology for the production of Drop-in Fuels, Bio-chemicals and Ethanol

2012+



Main sections developed in R&D

1. **Agronomy:** Field experimentation. Best energy crops identification and characterization.
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.

Second generation BIOethanol process: demonstration for the step of Lignocellulosic hYdrolysis and FErmentation

Univ. Lund-SE (TAURUS-SE)
(Microorganism Fermentation);

ENEA - IT
(Pretreatment);

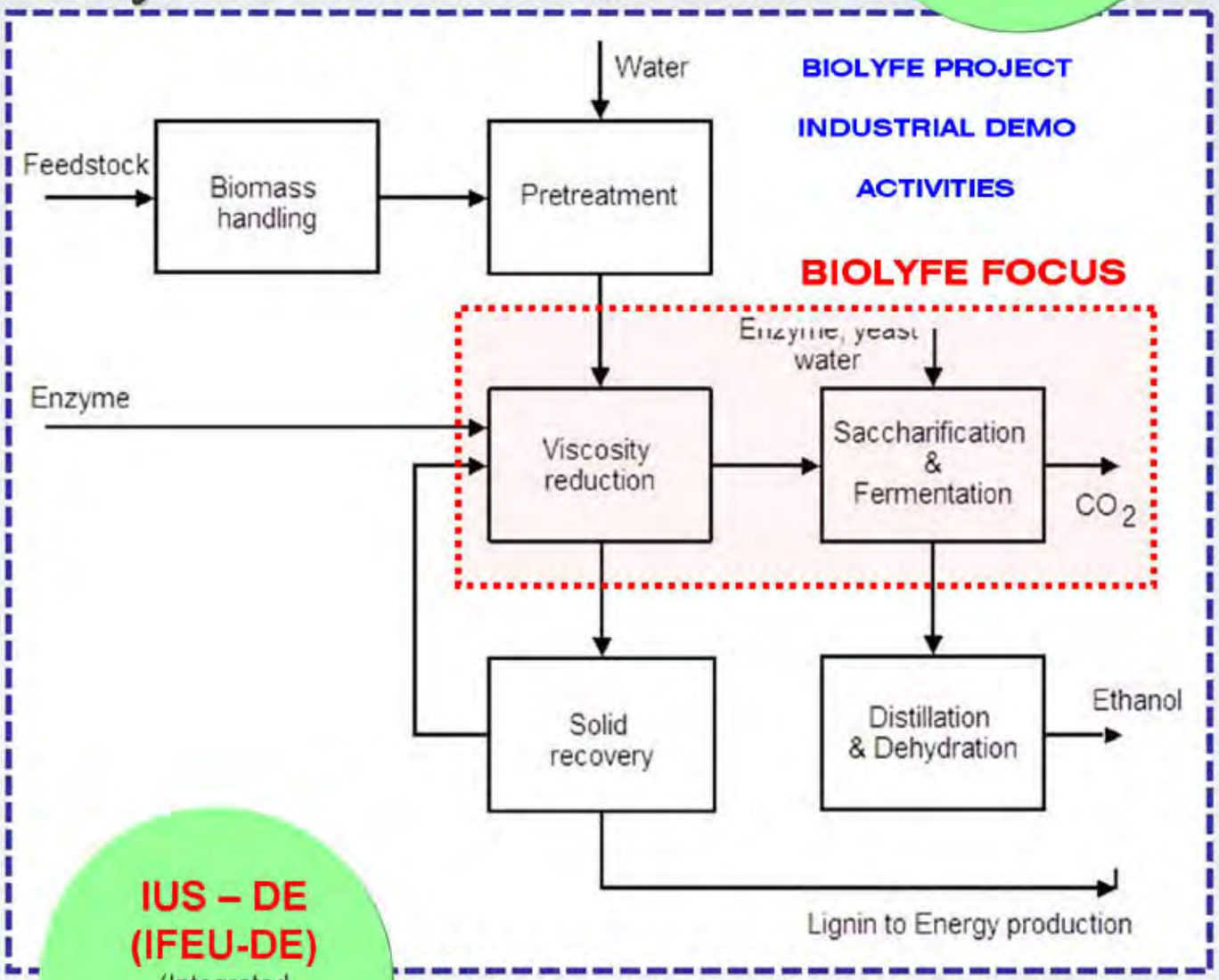
Agriconsulting IT
(biomass production);

WIP – DE (ETA-IT)
(Dissemination);

Novozymes DK
(Enzymes);

Chemtex - IT
(***Coordinator***, Second generation Bioethanol demo unit);

IUS – DE (IFEU-DE)
(Integrated assessment);



EC-FP7

PRELIMINARY RESULTS

Arundo *donax* nursery (~10 years old) in Columbus Ohio

Productivity: 43.1 dry T/ha

Arundo Donax
2009 - 3rd year
dry_ton/ha/y

Collaborations on Biomass Pretreatment (SE)

ENEA: steam explosion unit (300 kg/h biomass in)

✓*Since 1992 ENEA owns and operates this pilot unit at the premises of the Trisaia R&D Center.*

✓*ENEA has developed specific skills and expertise on this technology, investigating the main operational parameters needed to control this biomass pre-treatment steps.*

PRIT (Industria 2015) project:

✓*Min.for Econ.Devevelopment*

✓***CREAR** (Univ.of Florence): energy valorization of lignin residue*

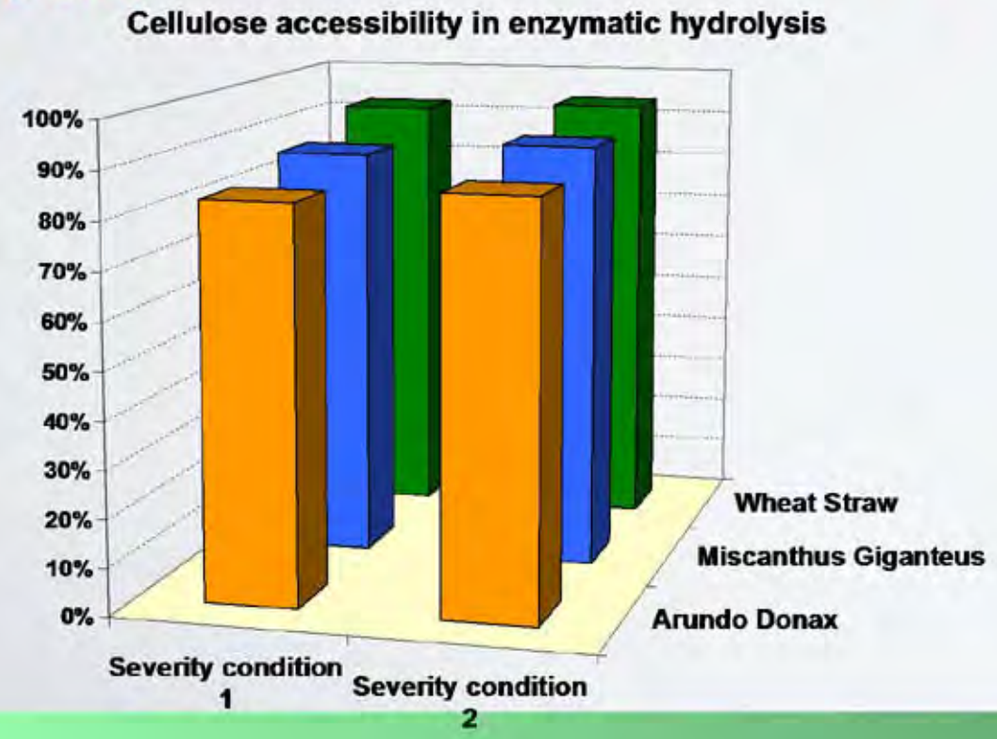
INDUSTRIA 2015

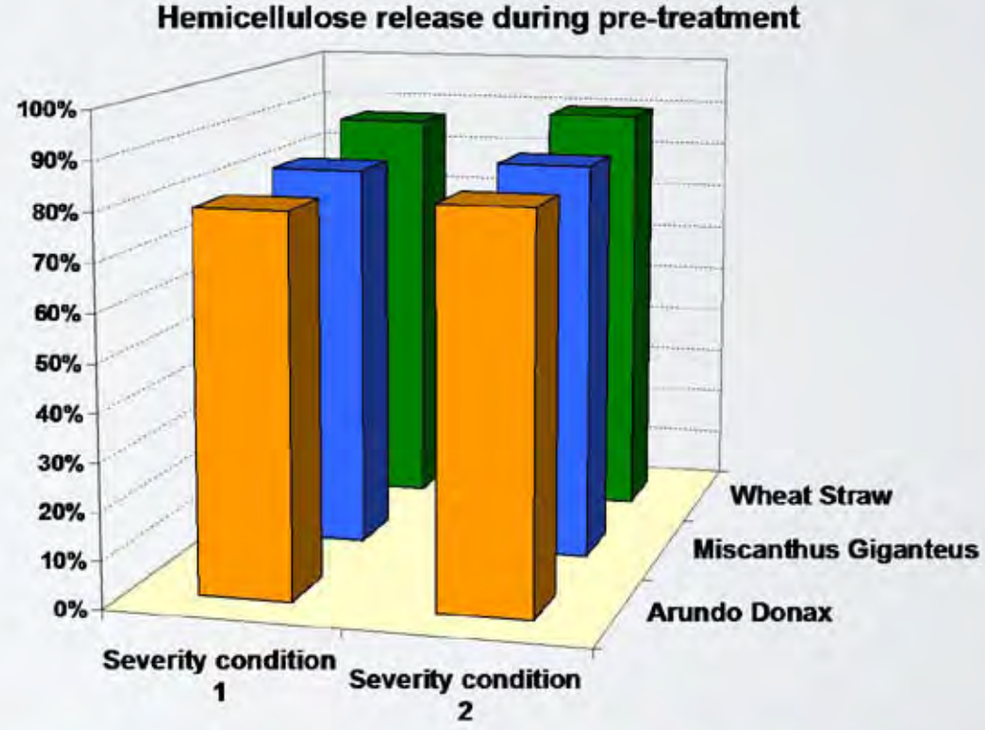
PROESA™ Technology
Key Features

CAPABILITY TO USE A LARGE VARIETY OF BIOMASS AS COLLECTED
(same hardware, change in process conditions only)

RUNNING ON A CONTINOUS PILOT SCALE IN RIVALTA LAB SINCE JUNE 2009

Pre-treatment pilot plant can be fed with several material with a size up to 5 cm.

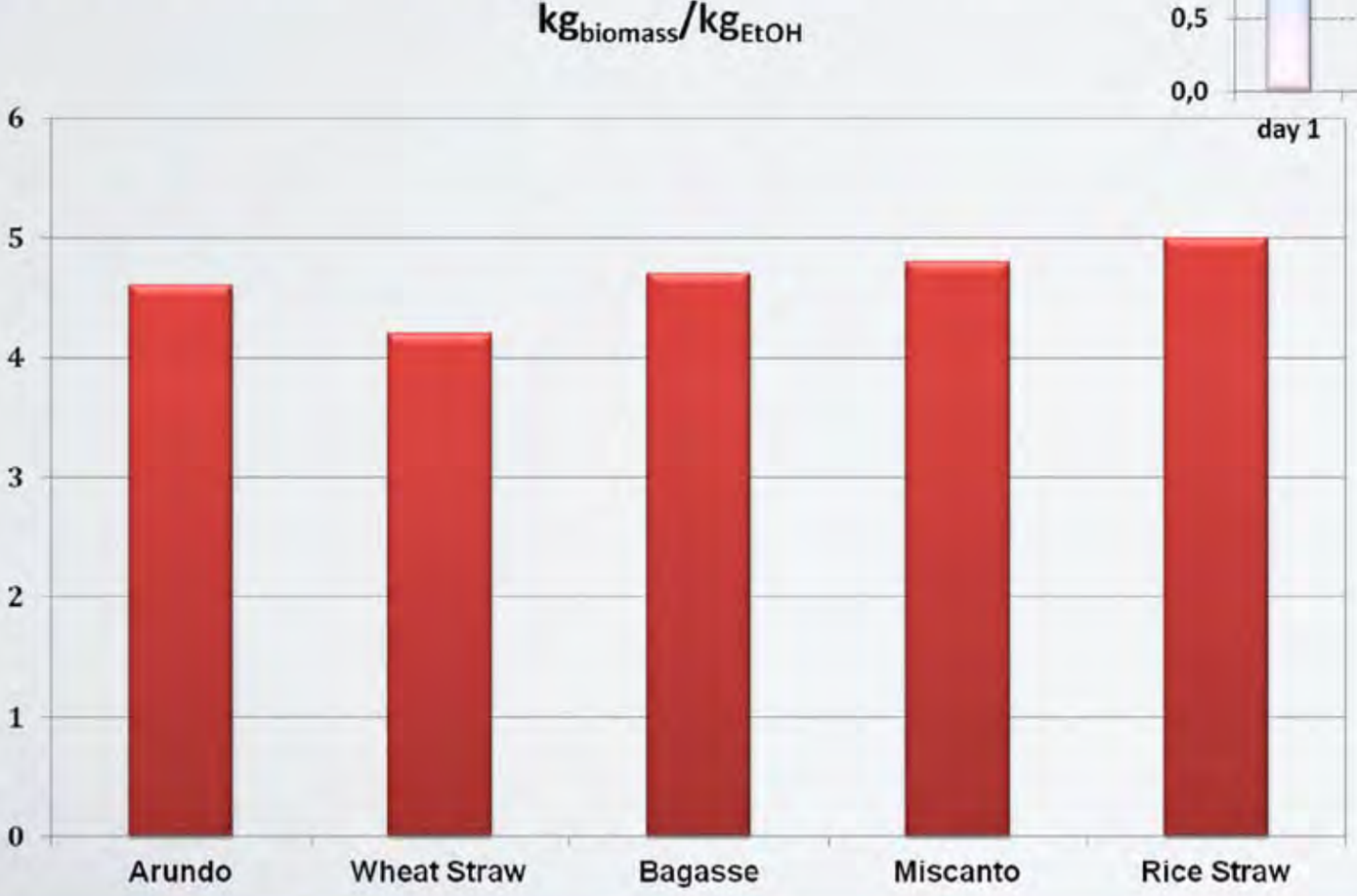


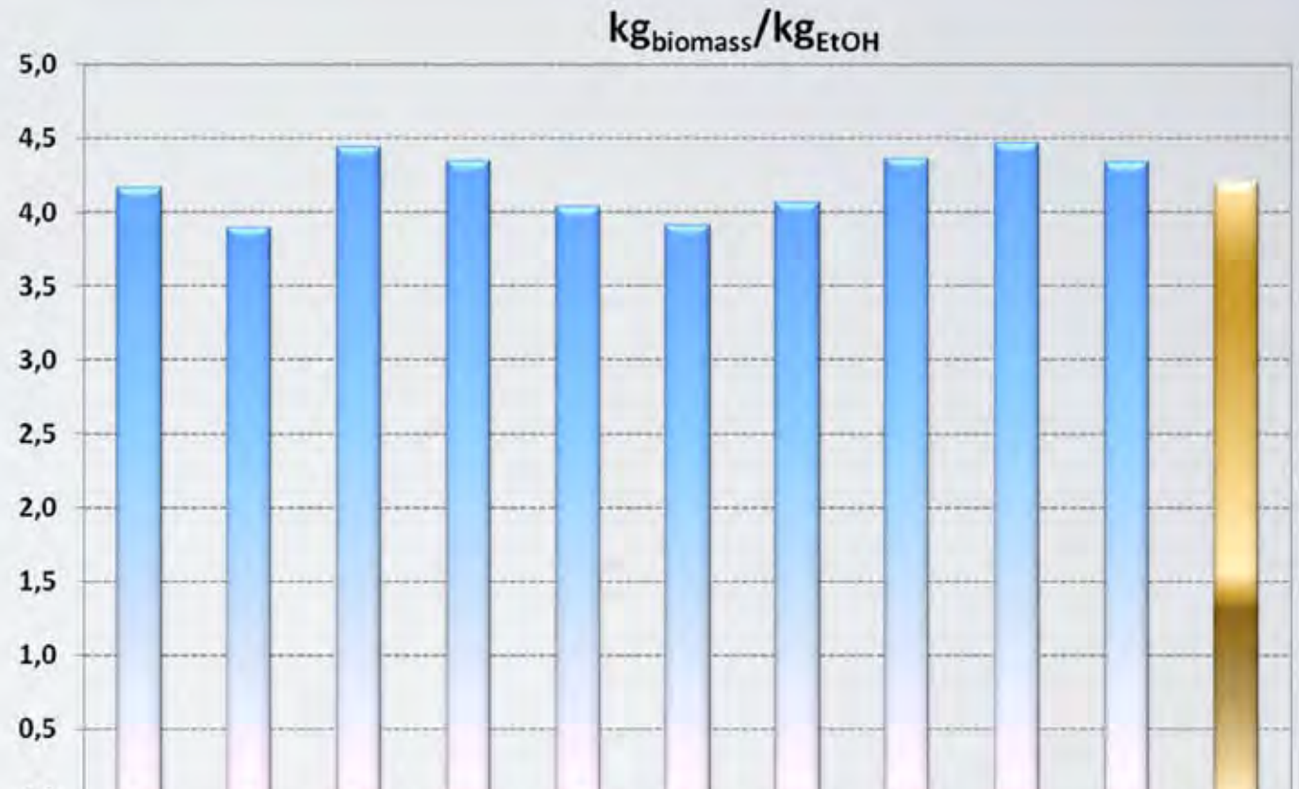


Different feedstocks show a similar behaviour in pretreatment

PROESA™ Technology: Ethanol yields

GOOD yields also with different biomasses





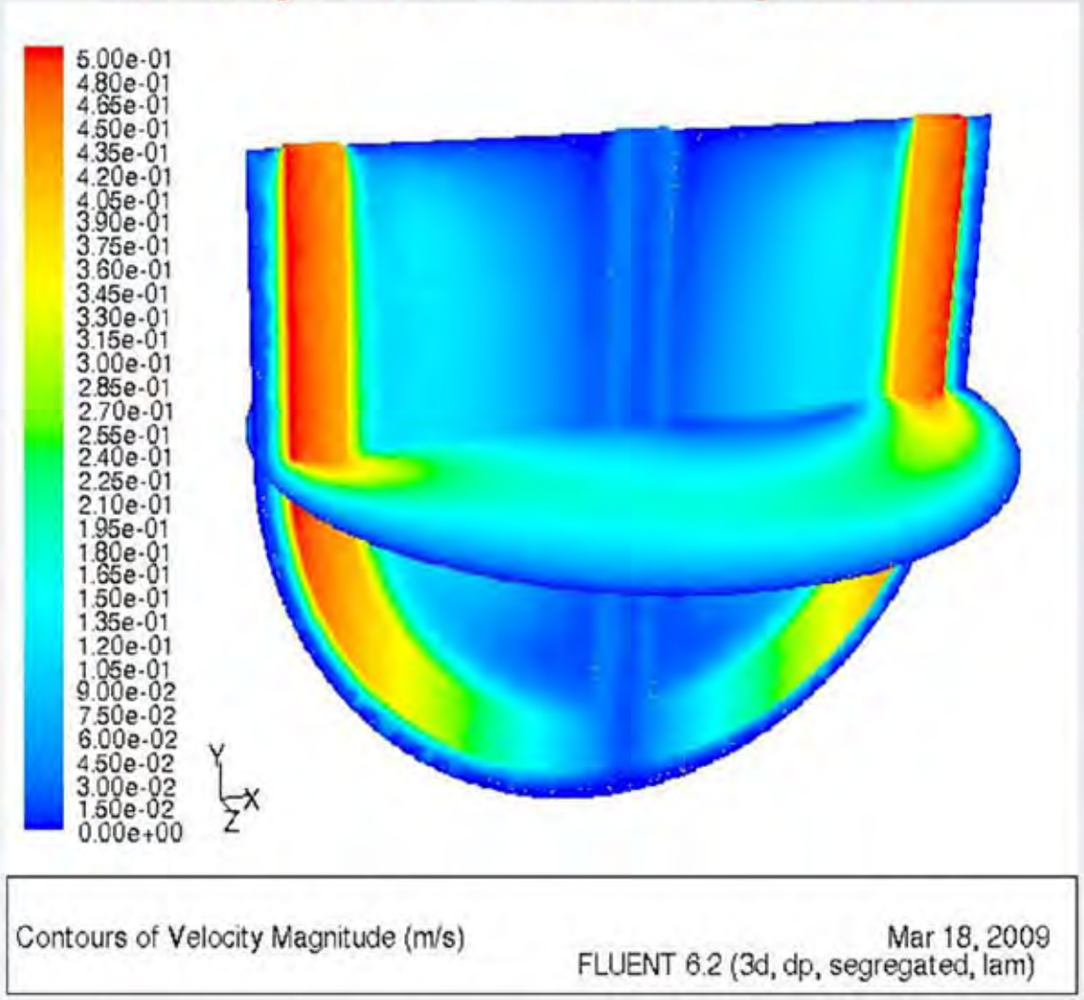
GOOD process stability on long run

PROESA™ Technology Key Features

Lab. High Solid Viscosity Reduction

Viscosity reduction

Velocity Field – Stationary Model



Viscosity determination of pretreated material during hydrolysis by CFD Modelling.

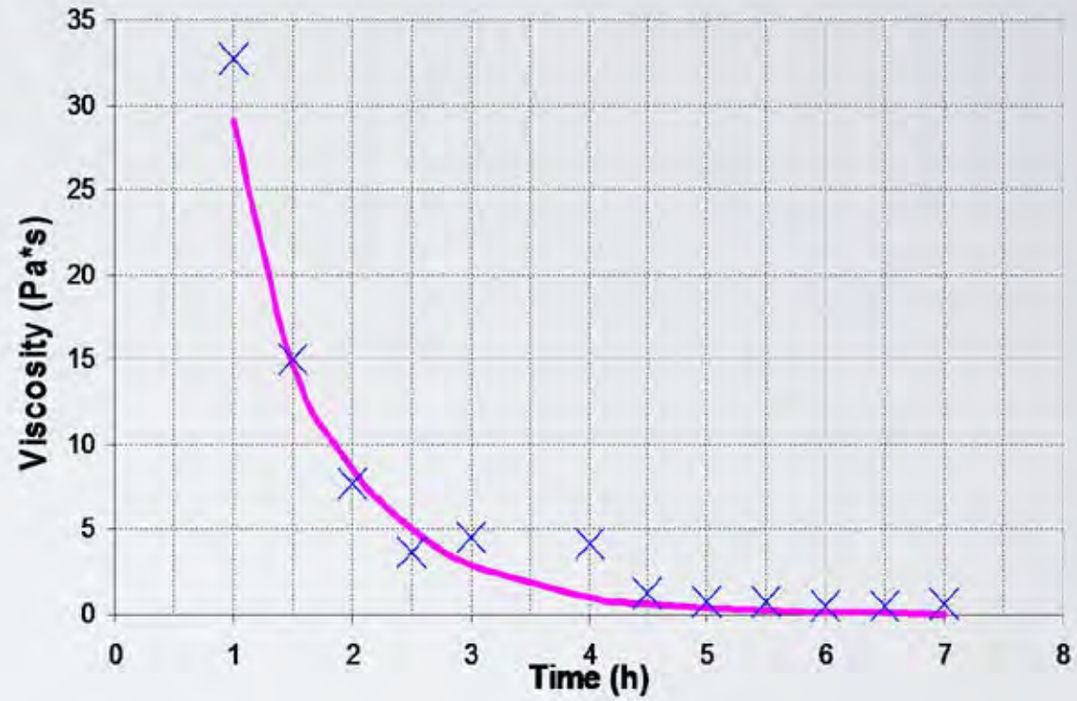
70 RPM, Moving Reference Frame 735.846 cells – unstructured.

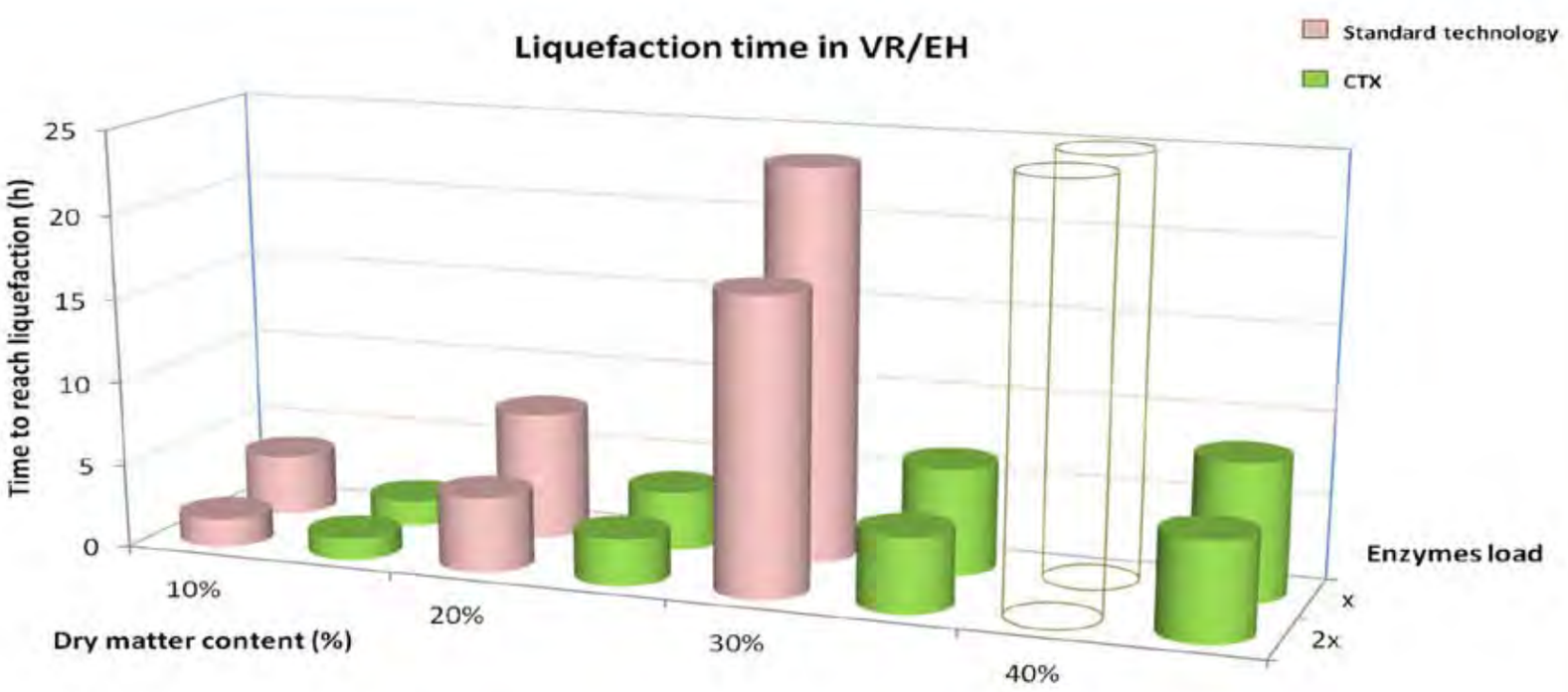
PROESA™ Technology
Viscosity reduction

Advantages of new continuous

high solid Viscosity Reduction concept:

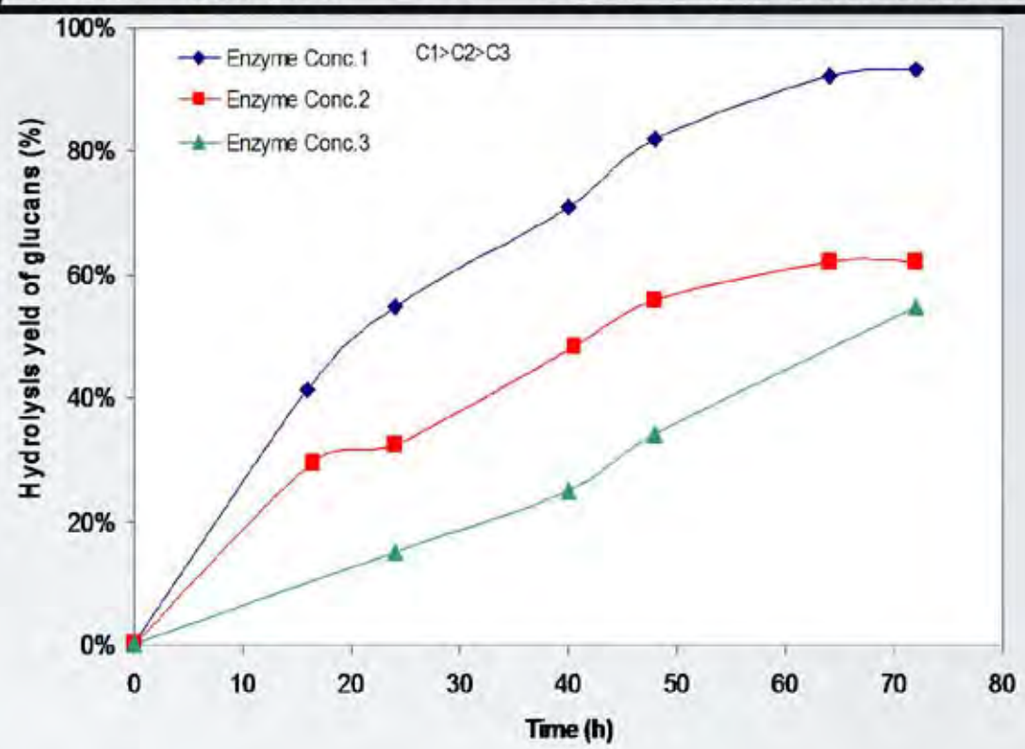
- Possibility to work at dry matter contents up to 40%
- Very low energy consumption for agitation
- Material is liquefied in less than 8 h even at low enzyme load
- Easy pH and temperature control

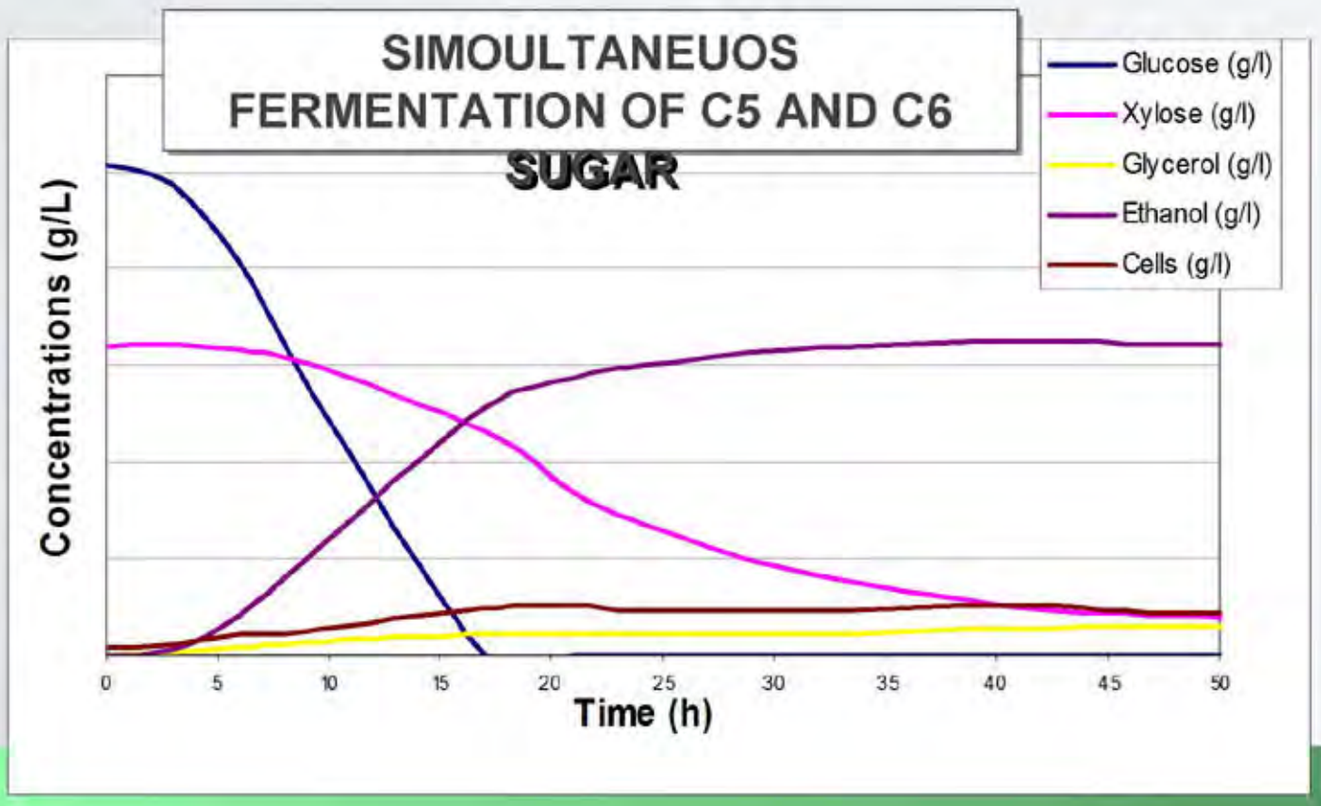




R&D on enzymatic hydrolysis and C5-C6 fermentation

PROESA™ Technology Key Features





Available MO's will assure fermentation of C5 and C6 sugars.

The fermentation time will be comparable to fermentation time of first generation plants

The beer will contain more then 6% of EtOH, assuring an efficient conversion and low cost during the separation steps compared to other 2nd gen EtOH technologies

PROESA™ Technology - Key Features

✓ENERGY INTEGRATION THANKS TO HIGH EFFICIENCY LIGNIN BURNING
✓PURE LIGNIN FOR CHEMICALS

Lignin from the process has enough energy content to meet all plant energy demand.

Design of each plant will include a power generation unit.

Lignin from the PROESA™ technology is free from Sulfur, Chlorine and Ammonia and can constitute an unique base for producing chemical from biomass.

CONSTRUCTION OF THE DEMONSTRATION PLANT

David Chiaramonti

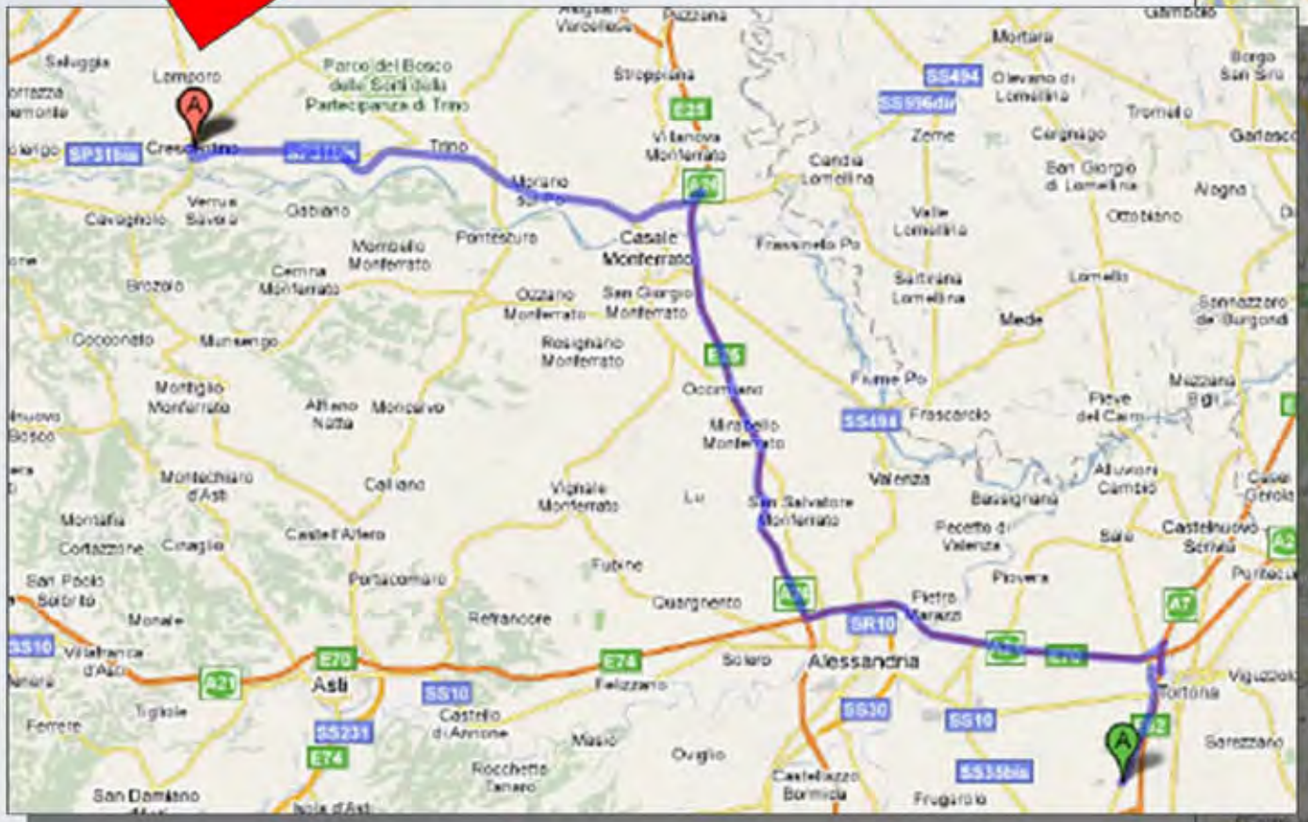
April 12, 2011: Ground-Breaking of the first 40.000 ton/y plant

EC-FP7

BIO LYFE

BIOLYFE Demo Plant Location

Crescentino, Piemonte



EC-FP7

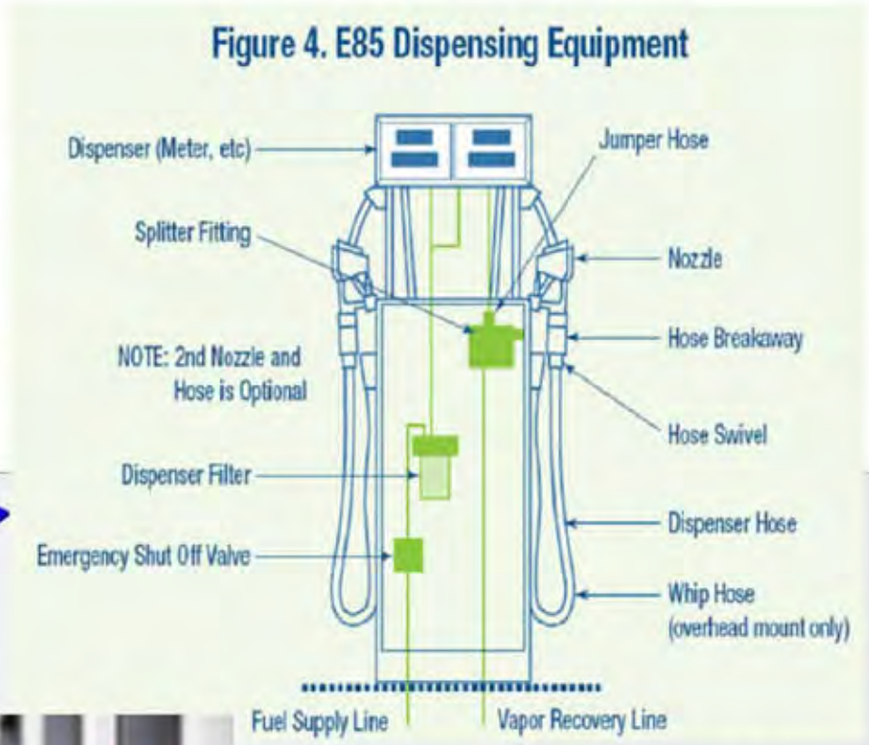
BIOLYFE

40.000 t/y First Plant- Key Features

- **Production based on Arundo Donax (~5000 ha) and Wheat Straw (300.000 t/y) locally available.**
- **Plant located 70 km from nearest refinery.**
- **Plant will incorporate all technology features developed during the R&D project phases.**
- **Plant will demonstrate at commercial scale the new pretreatment technology (PRIT).**
- **Plant will incorporate innovative Hydrolisis and Fermentation step as part of the BIOLYFE FP7 Project.**
- **Plant will sell Dry Ethanol to major oil company/ies.**
- **51.000 ton of CO_2 emission saved per year. 40,000 t/y Ethanol = 6.800 car without CO_2 emission.**

Vehicle fleet

Installation of E85 Pump

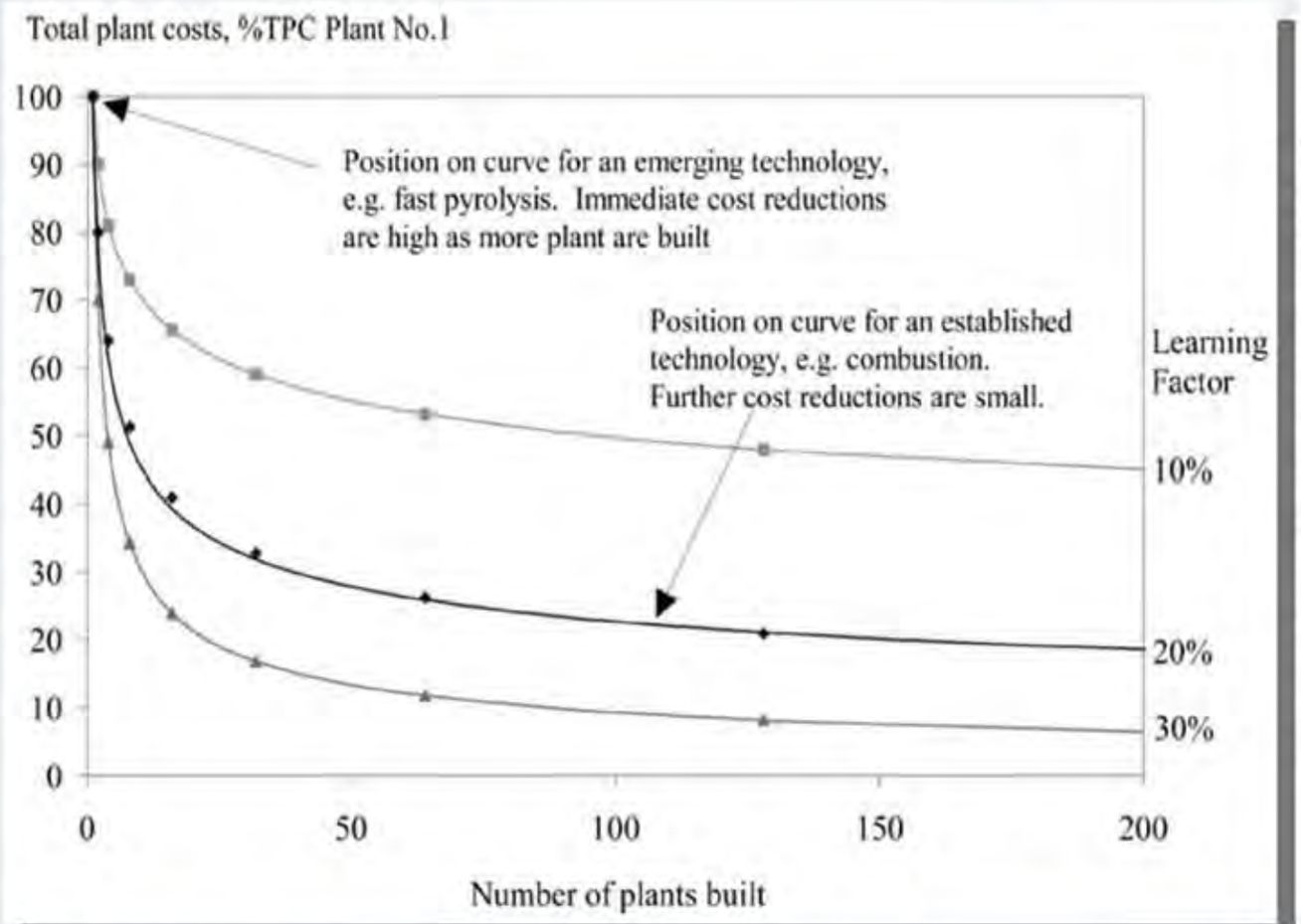


Biolyfe partners:

WIP - Eta Florence

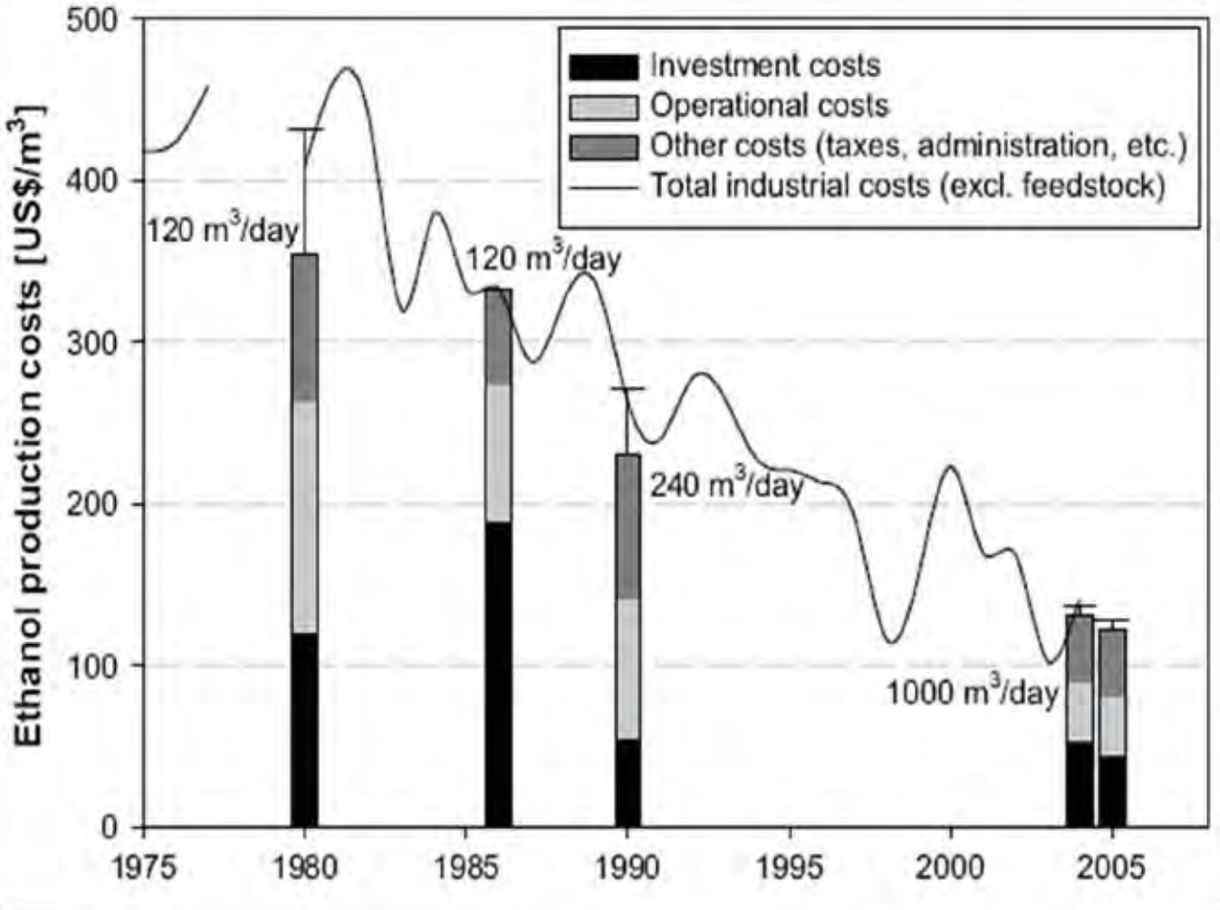
EC-FP7

Large opportunities for improvement of new chains/technologies exist!



A.A.V.V.Bridgwater et al, 2004

Cost breakdowns of the industrial ethanol production process excluding feedstock costs (Brasil)



Van den WallBake et al, 2009

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RE·CORD

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Thanks for your attention!

RE·CORD

Research for Renewables