Second generation ethanol

The PRO.E.SA. Project: state of research towards realization of the plant

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Main objective: Developing a complete crop-to-ethanol value chain through a conversion technology able to transform selected ligno-cellulosic material into bio-ethanol in a sustainable way.

Timeframe: 5 years (2007÷2011)
**PRO.E.SA: Steps**

- **2007-2008**: Scouting, testing and development of technology on lab scale.
- **2009**: Construction and test on continuous pilot plant.
- **2010**: Construction of DEMO plant. 30,000-40,000 t/y.
New R&D and Technology center for Renewable Resources.

3000 m² dedicated to renewable

Fully equipped analytical and fermentation laboratories

45 peoples dedicate to R&D activities
Main section analyzed in R&D:

- Experimentation on field and selection of best energy crops;
- Pretreatment developing and testing;
- High solid content enzymatic hydrolysis reactor design;
- Test of enzymes with industrial partner;
- Fermentation test with industrial partner.
**Biomass:**

- Experimentation on field done and individuated *Arundo Donax* and *Fiber Sorghum* as best energy crops candidate for ethanol production;
- Expected 50 t/ha of dry matter;
- Low input in terms of irrigation and fertilization;
- Developed model for logistic of biomasses.
TECHNOLOGY: 2008 achievements

40% yield/ha increase

2007 Experimentation

2008 Experimentation
**Pretreatment:**

- Technical/economical evaluation and comparison of different existing pretreatments on selected biomass species
- Lab and/or pilot scale tests on existing pretreatments on selected biomass species
- New pretreatment technique developed where the formation of fermentation inhibitor compounds is limited
TECHNOLOGY: 2008 achievements

Pretreatment: new pretreatment concept

Comparison between new pretreatment concept and Steam Explosion (SE)
Advantages of new pretreatment concept:

- Minimal request of feedstock size reduction;
- High flexibility towards different feedstock;
- Possibility to reduce energy consumption;
- No chemical addition - no special construction material required;
- Easy to scale up.
Enzymatic hydrolysis:

- Defined best enzyme package for selected and pre-treated biomass.
- Optimization of pre-treatment and optimization of enzyme package allowed up to 96% yield on glucans.
- Modeling and development of high solid concentration enzymatic hydrolysis reactor
Enzymatic hydrolysis:

Test on Arundo pretreated according to M&G process

Glucose yield: 96%
Xylose yield: 99%

Test on Sorghum pretreated according to M&G process

Glucose yield: 97%
Xylose yield: 99%
**TECHNOLOGY: 2008 achievements**

**Fermentation:**

- Scouting and testing of available technologies;
- Industrial key technology partner selected;
- Successful preliminary results.
Fermentation:

Test on Arundo pretreated and hydrolyzed according to M&G process

Ethanol yield: 95%

Test on Sorghum pretreated and hydrolyzed according to M&G process

Ethanol yield: 93%
PRO.E.SA: Steps

2007-2008
Scouting, testing and development of technology on lab scale

2009
Construction and tests on continuous pilot plant.

2010
Construction of DEMO plant
30,000-40,000 t/y
**PRO.E.SA: targets for 2009**

**2009:** Collection of data using batch and continuous pilot plants.

Pretreatment and high solid enzymatic hydrolysis batch reactor

Pilot plant area for pre-treatment and high solid enzymatic hydrolysis under construction

*Ready by: late spring 2009*
PRO.E.SA: targets for 2009

**Biomass:**
- Large scale trial on more than 200 ha;
- Scale-up of energy crop program for feed Demo plant;
- Prove on large scale biomass logistic model.

**Process:**
- Test pretreatment on continuous pilot plant (20 Kg/h);
- Test of high solid content enzymatic hydrolysis on continuous pilot plant;
- Definition of key parameters necessary for the scale-up and design of demo unit.
Process design:

- Confirmation of overall process design

- Generation of data needed to confirm process models
PRO.E.SA: Steps

- **2007+2008**: Scouting, testing and development of technology on lab scale
- **2009**: Construction and tests on continuous pilot plant
- **2010**: Construction of DEMO plant.
  - 30,000 - 40,000 t/y
Demostration Unit:

- 30,000-40,000 t/y of ethanol
- 80 M€ investment
- 18 months from breaking ground to start-up

First industrial/demo second generation bioethanol plant in southern Europe using most advanced conversion technology.
PRO.E.SA: Partnership

CREAR, ENEA, CNR, Politecnico di Torino, Industrial Partners

Agriconsulting, ENEA, Univ. Lund, IFEU, WIP, Industrial Partners

Pretreatment

Enzymatic Hydrolysis

Fermentation

Separation

Demonstration Unit – 30 kTy


Conafor, ICE - Messico

Univ. Federal de Viçosa, Empresa Brasileira De Pesquisa Agropecuaria, Politecnico di Torino

Base R&D / Agronomical R&D / Pilot plant

Imperial College of London, Univ. Federal de Viçosa, Empresa Brasileira De Pesquisa Agropecuaria, Slovenska Technicka Univerzita Bratislave, Bioethanol Science and Technology Center

Politecnico di Torino Uni.GE

Univ. Avogadro AL

Univ. Piacenza, Industrial Partners
CONCLUSIONS

2008  
a possible challenge  
*una sfida possibile*

2009  
a realistic challenge  
*una realtà possibile*

2010  
plant under construction in Italy  
*impianto in costruzione in Italia*