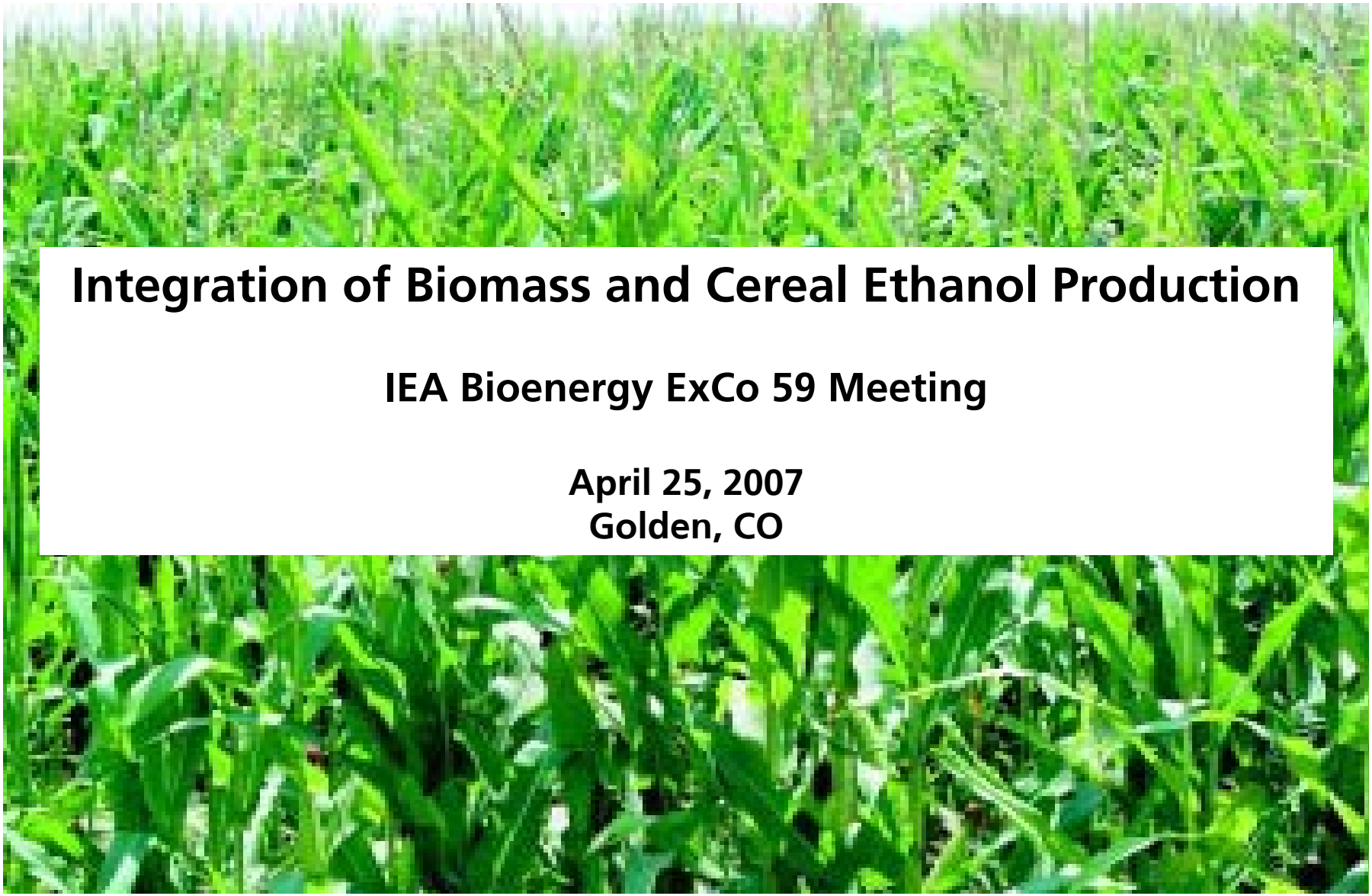


Integration of Biomass and Cereal Ethanol Production

IEA Bioenergy ExCo 59 Meeting

April 25, 2007
Golden, CO

Outline of presentation

- Overview of Abengoa and Abengoa Bioenergy
- Abengoa Hybrid Starch and Biomass approach
- Process Development and Commercial Demonstration Projects
- Strategies for Overcoming Barriers to Biomass Ethanol Commercialization

- Founded in 1941 in Seville, Abengoa is a technology company applying innovative solutions for sustainable development in the infrastructures, environment and energy sectors.

- Abengoa is present in over 40 countries, operating through its 5 business units: Bioenergy, Environmental Services, Solar, Information Technologies, and Industrial Engineering and Construction.

- Abengoa Bioenergy Corporate Headquarters locate in Chesterfield, MO.

- Innovation drive as a springboard for sustained growth.

ABENGOA BIOENERGY R&D

ABENGOA

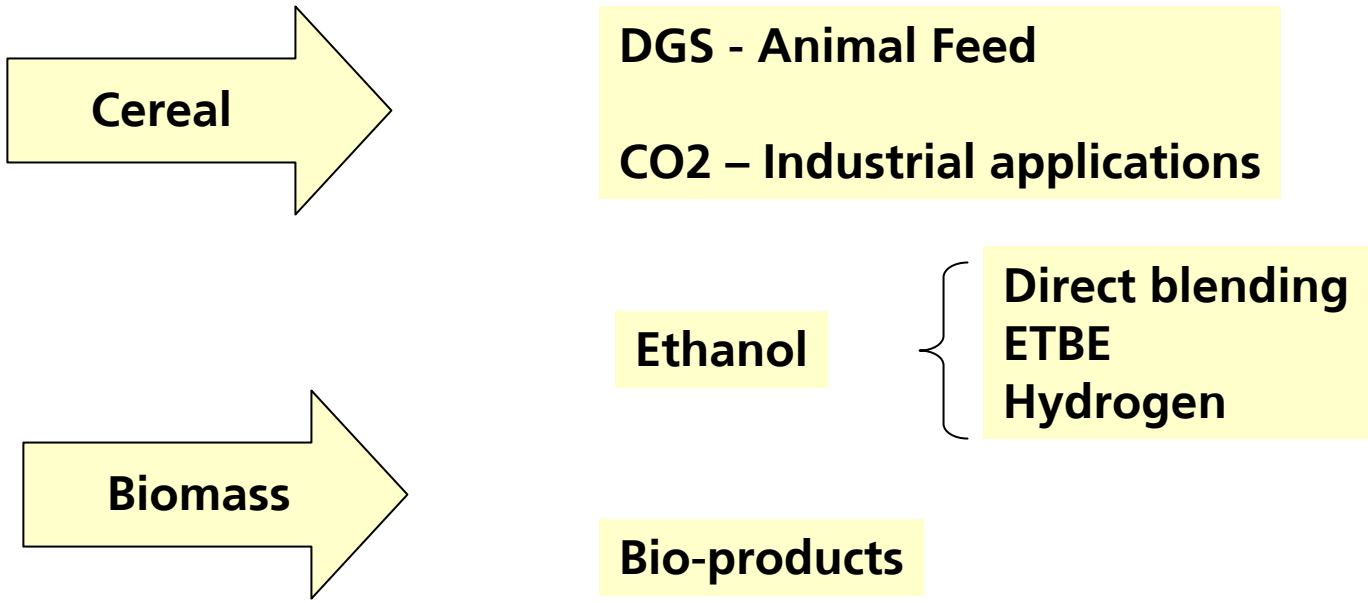
Bioenergy	Environmental Services	Solar	Information Technologies	Industrial Engineering and Construction
Europe's No. 1 Bioethanol Producer; No. 5 in the US	Leader in industrial waste treatment and environmental engineering	Electricity generation from solar power	Leader in energy, traffic, transport, environmental	Leader in Spain and Latin America

Sustainable Development

Information and Knowledge

Creation of Infrastructure

Ethanol production from cereal and cellulosic biomass



Abengoa Bioenergy´s Production Capacity

Production Facilities in EU

EU (Ml)	2005	2006	2007
Production	326	526	756
Construction	200	230	

- Cartagena

- La Coruña

- Salamanca

- ETBE Huelva

Production Facilities in the U.S.

US (Ml)	2005	2006	2007
Production	420	420	745
Construction	325	325	

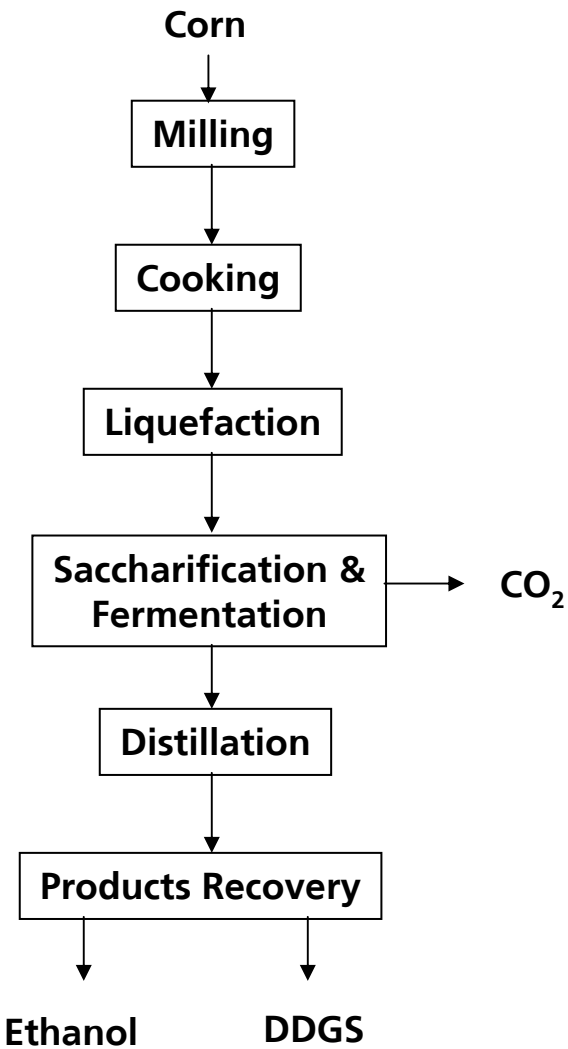
- York, NE

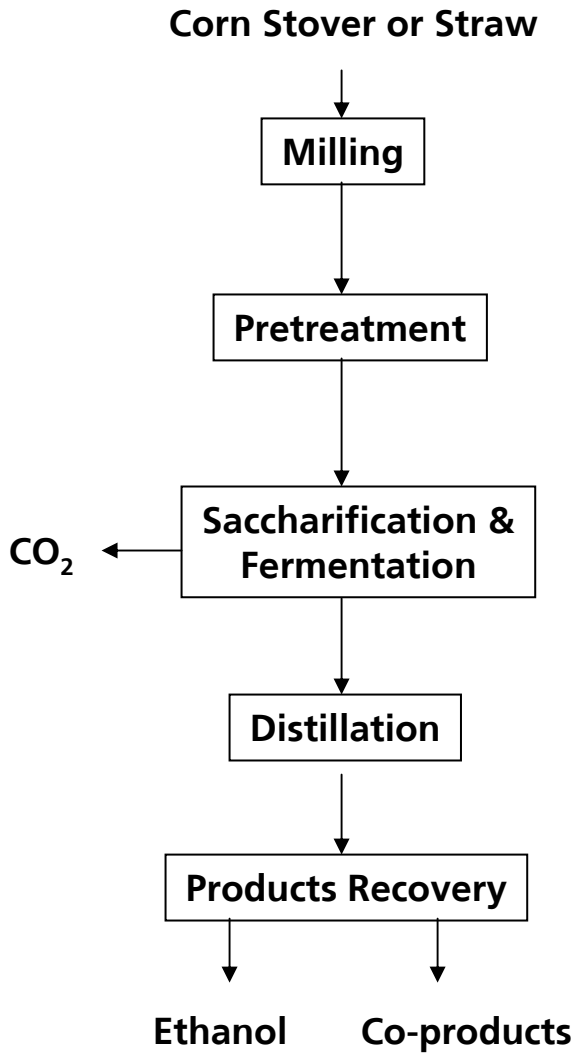
- Ravenna, NE

- Colwich, KS

- Portales, NM

Development of Efficient Enzymatic Conversion Processes

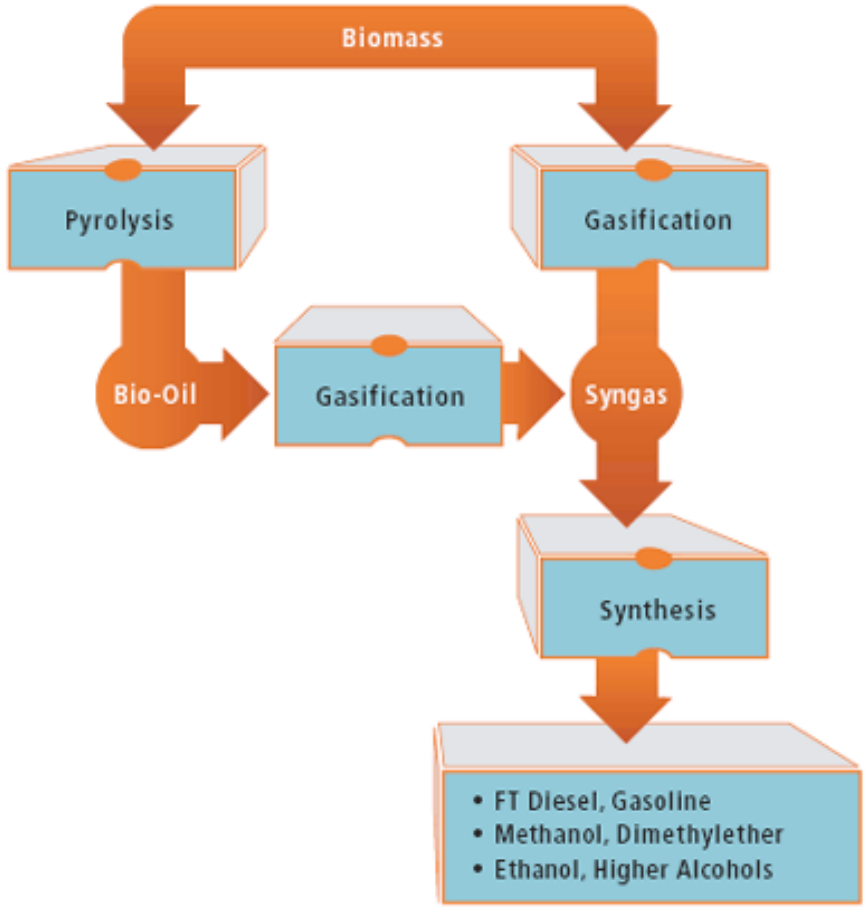




Medium/Long Term Development

- Development of a thermochemical pathway for conversion of any carbonaceous feedstock to ethanol

- Gasification can make use of various carbon sources



- **DOE-sponsored Project: York Biorefinery Pilot Plant**
  - 1.5 tonne/d biomass: biomass to ethanol and co-products
  - Feedstock: corn stover, wheat straw, switch grass, etc.

- **BCyL Biomass Ethanol Commercial Demonstration Plant (Babilafuente, Salamanca, Spain)**
  - Feedstock: 70 tonne/day wheat straw
  - 5 million L/y ethanol

- **Various Gasification, Catalyst Development, and Ethanol Reforming projects (bench and pilot plant)**

- **Hybrid Starch and Biomass Commercial Plant: Conceptual design phase**
  - 700 tonne/day (wheat straw, corn stover, switch grass, etc.)
  - Integrated with cereal ethanol plant
  - Incorporate enzymatic conversion and gasification

York Pilot Plant

BCyL Biomass Ethanol Plant

Integrated with Cereal Plant

Biomass Conversion Challenges

1. Biomass feedstock is complex, varying, and bulky
2. Feedstock collection logistics
3. Biomass is more recalcitrant compared to starch, which leads to more severe pretreatment
4. Cellulose hydrolysis is slower and more expensive than starch hydrolysis
5. Complexity of fermenting hexose and pentose in biomass hydrolysate
6. Technical complexities result in higher processing costs
7. Co-product development for biomass is in early development stage

Abengoa Fuel and Feed Model

- The dry mill ethanol technology is an excellent proven fuel and feed platform for biomass technology. Abengoa is taking advantage of the opportunity and adding value by building new capabilities.

- Integration of starch and biomass conversion will reduce the initial risks in commercialization of new biomass technologies.

- Biotechnology provides for the optimization of the feedstock and the process for fuel and feed applications;

  - Enzyme engineering, protein content, lower lignin, higher cellulose, fermentation organism, etc.

- Future biorefineries will take advantage of plant and industrial biotechnology to increase capabilities and lower production cost.

Conclusion

- There are many technical and economic hurdles for biomass ethanol production
- These hurdles can be overcome with further process and product development
- The future of biomass conversion to fuel, feed, and chemicals looks very promising
- For near term commercialization, integration with cereal ethanol production significantly improves the overall process economics.
- Abengoa unique approach to hybrid starch and biomass ethanol technology development and commercialization should give us a competitive advantage over stand-alone biomass-to-ethanol technologies.

Acknowledgement

- The US Department of Energy Biomass Program provides cost shares for the York Pilot Plant construction and operation.

- The BCyL Biomass Ethanol Demonstration Project receives funding from the European Commission.