

ABENGOA BIOENERGY NEW TECHNOLOGIES



From research and demonstration to the first commercialization plant: Abengoa Bioenergy's experience in 2nd generation bioethanol

November, 2012

Carmen Millan Chacartegui

carmen.millan@bioenergy.abengoa.com

ABENGOA BIOENERGY

1. Abengoa

2. Abengoa Bioenergy

3. Second generation biofuels

4. Conclusions

ABENGOA BIOENERGY

Abengoa

Abengoa (MCE: ABG) is an international company that applies innovative technology solutions for sustainable development in the energy and environment sectors, generating electricity from the sun, producing biofuels, desalinating sea water and recycling industrial waste

Sectors

Energy

76 %



20 MW CSP Tower (Seville, Spain)

- Power transmission
- Solar
- Cogeneration
- Biofuels

Environment

24 %

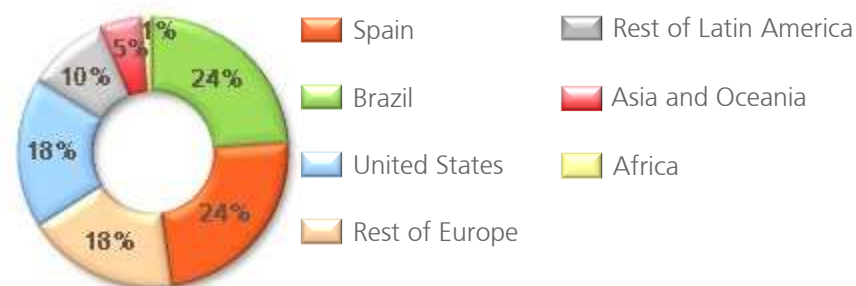


200,000 m³/day desalination plant. (Honnaine, Algeria)

- Desalination
- Industrial waste recycling

Geographies

Revenues (%)



Personnel

A total of 22,960 people



The global biotech e

Note: figures as at September 2011.

Successful strategy based on three activities

1 Engineering and construction

- 70 years of experience.
- Proprietary know-how.
- 1st international contractor in power and 1st in transmission and distribution.

2 Concession-type infrastructure

- Power generation plants, desalination plants and power transmission lines.
- Very low market risk.
- An average of 27 years of regulated revenues.

3 Industrial production

- Industrial technology businesses such as biofuels, industrial waste recycling or solar energy.
- High growth markets.
- Market leadership.



ABENGOA BIOENERGY

. Abengoa

2. Abengoa Bioenergy

3. Second generation biofuels

4. Conclusions

ABENGOA BIOENERGY

We have evolved...

1G

- Abengoa identifies need for renewable alternatives.
- Acquisition of High Plains Corporation in U.S.
- 650 MI (170 MG) capacity in US and EU.



1995-2001

- Organic growth up to 1,000 ML (265 MG) capacity in US and EU.



2002-2006

- Acquisition Dedini Agro, Brazil.
- Assets in 5 countries, three geographies.
- Total 3125 MI (825 MG) capacity in operation.
- Operating 6 cogen facilities (259 MW), with 2 of them powered by biomass (140MW).

2007-2011

2012-2013

2004-2011

2001-2003

2G

- Lignocellulosic ethanol identified as strategic to cover future demand.
- Enzymatic hydrolysis technology selected as most promising one.

- R&D stages fulfilled:
 - York pilot plant.
 - BCyL biomass demo plant.
- R&D externally validated:
 - DOE \$160M grants.
 - 3 Spanish Cenit projects.
 - 16th major company within EU VII framework program.
- Complimentary technology included in the portfolio:
 - Enzymes & C5 fermentation.
 - Bioproducts.

- First commercial-scale ethanol plant.
- Technology license business.
- O&M services.
- Biorefinery as next goal.



The global biotech ethanol company.

ABENGOA BIOENERGY

...becoming the only global ethanol company

Biofuel Capacity = 380 MG/1440 ML

Feed capacity = 980 Kt



Biofuel Capacity = 50 MG/185 ML

Sugar capacity = 540 Kt

Cogen capacity = 140 MW



Biofuel Capacity = 395MG/1500 ML

Feed capacity = 885 Kt

Cogen capacity = 119 MW



Global

Biofuel (MGY): 825
Sugar (KTY): 540
Electricity (MW) 259
Feed (KTY): 1865

AB Advantages

- Large asset base
- Access to various geographies
- Logistic leverage/arbitrages
- Raw material alternatives
- Experienced team
- Risk management platform

Strong position through diversification

The global biotech ethanol company.

ABENGOA BIOENERGY

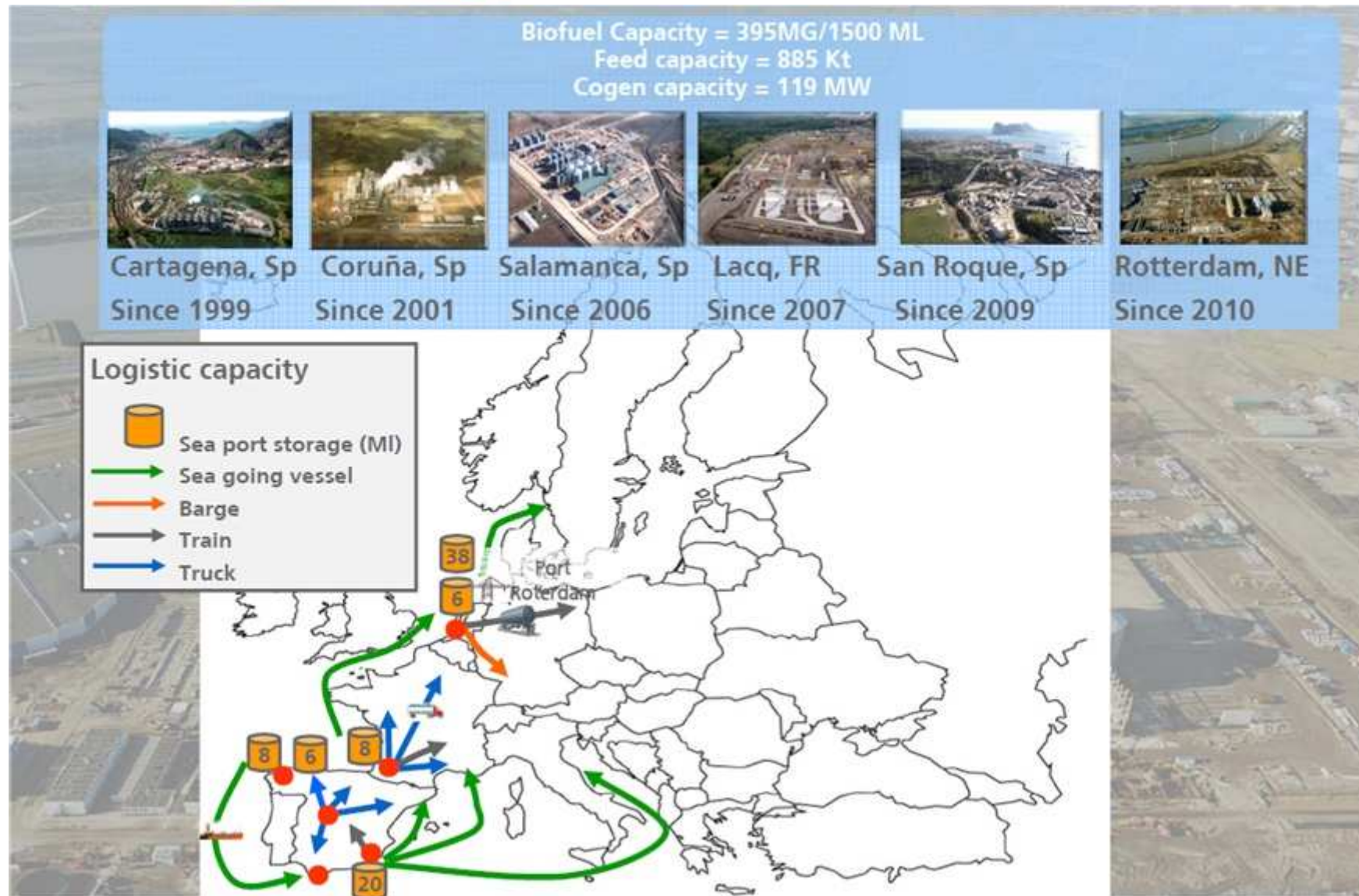
...with excellent position in the US



The global biotech ethanol company.

ABENGOA BIOENERGY

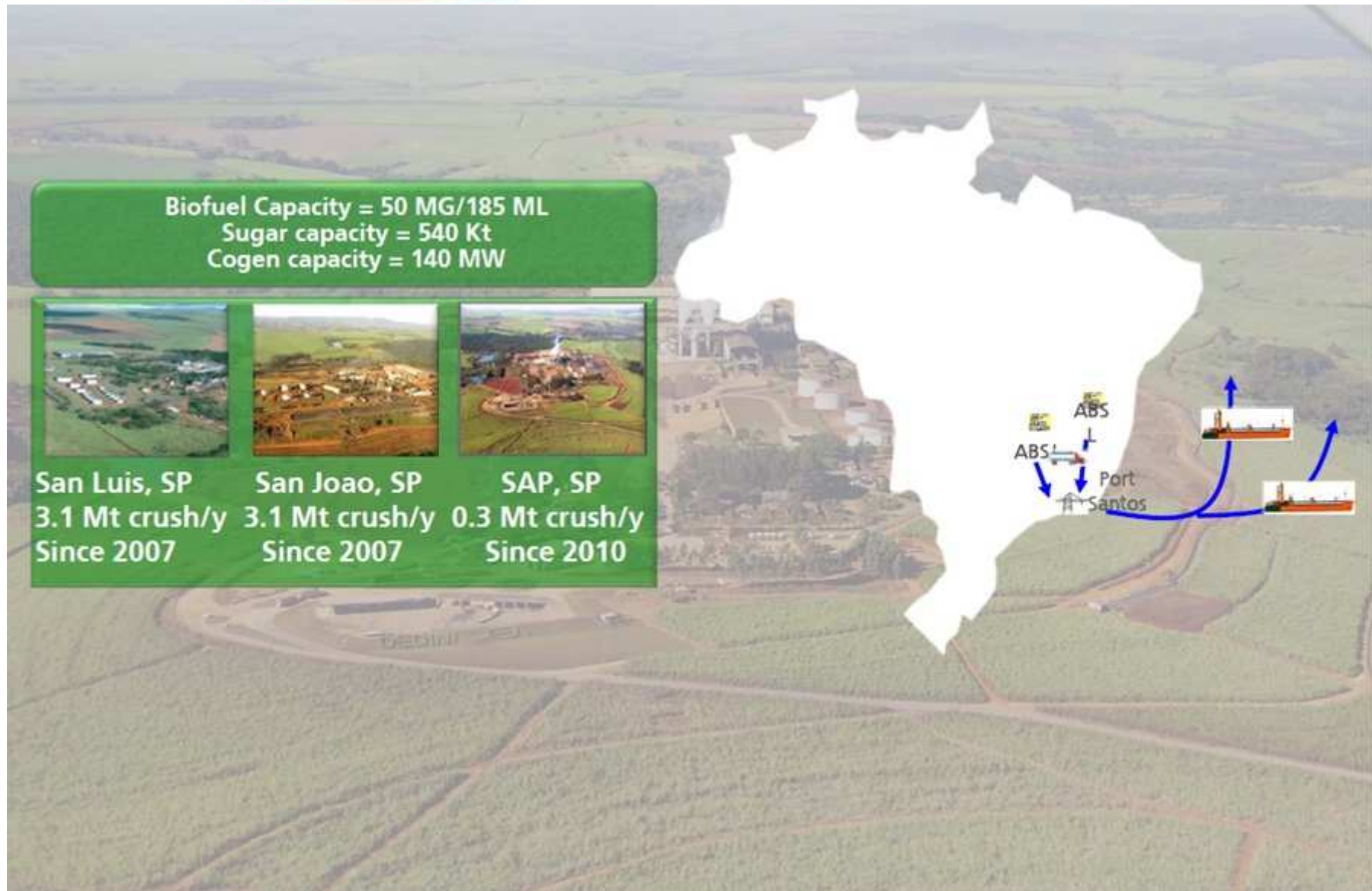
...leading the market in EU



The global biotech ethanol company.

ABENGOA BIOENERGY

...and being in the forefront in Brazil



The global biotech ethanol company.

1. Abengoa

2. Abengoa Bioenergy

3. Second generation biofuels

Biochemical pathway
Thermochemical pathway
Biorefinery concept

4. Conclusions

Technologies

1G vs 2G

1G

Examples

- Bioethanol production from cereal, sugarbeet and sugarcane.
- Biodiesel production from vegetable oils
- Pure vegetable oils.
- Biobutanol-acetone production from sugars.

Strength

- Well-known commercial technologies.
- Low transformation cost.
- There is still room for optimization.

2G

Examples

- Bioethanol production from lignocelulosic biomass and other agriculture residues.

Biochemical
path

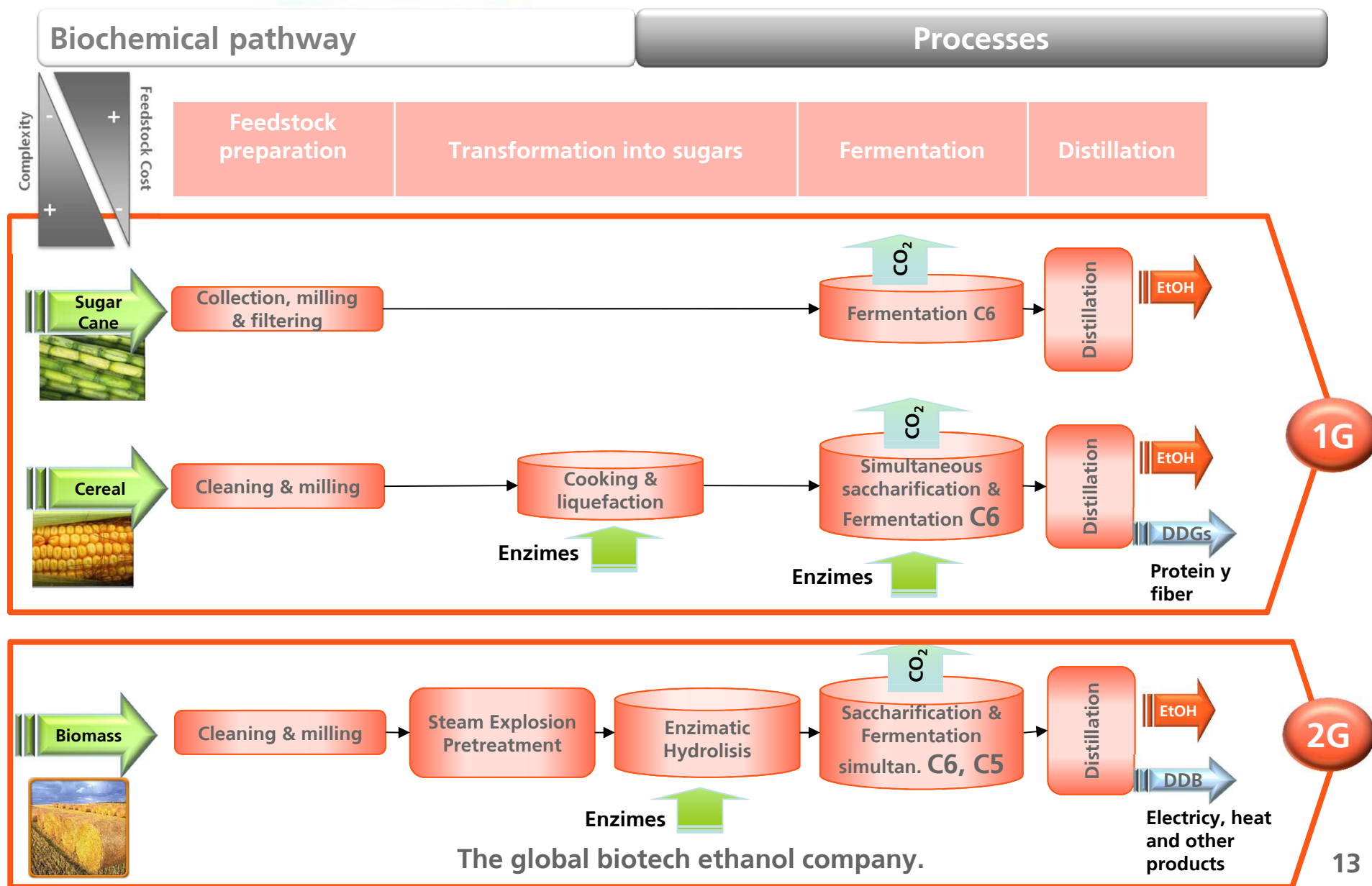
Thermochemical
path

Strength

- High energy efficiency and lifecycle improvements potential.
- Feedstocks low cost.
- Residual resources utilization potential.
- High improvement potential through development.

ABENGOA BIOENERGY

Innovative technology solutions for sustainability



Biochemical pathway

Definition

- The process is defined as the fractionation of the biomass into its main components (cellulose, hemicellulose and lignin) for further fermentation to ethanol of sugars.

Status:

- Inexistence of commercial technologies.
- Abengoa Bioenergy is worldwide leader in technology development. Only player with precommercial facilities:
 - York Pilot Plant– 0,08 MML.
 - Operating since 2007.
 - Salamanca Demo Plant– 5MML/year.
 - Operating since 2009.
 - Hugoton Commercial Plant – 100 MML/year.
 - Starting up by 2012 ending.

Justification:

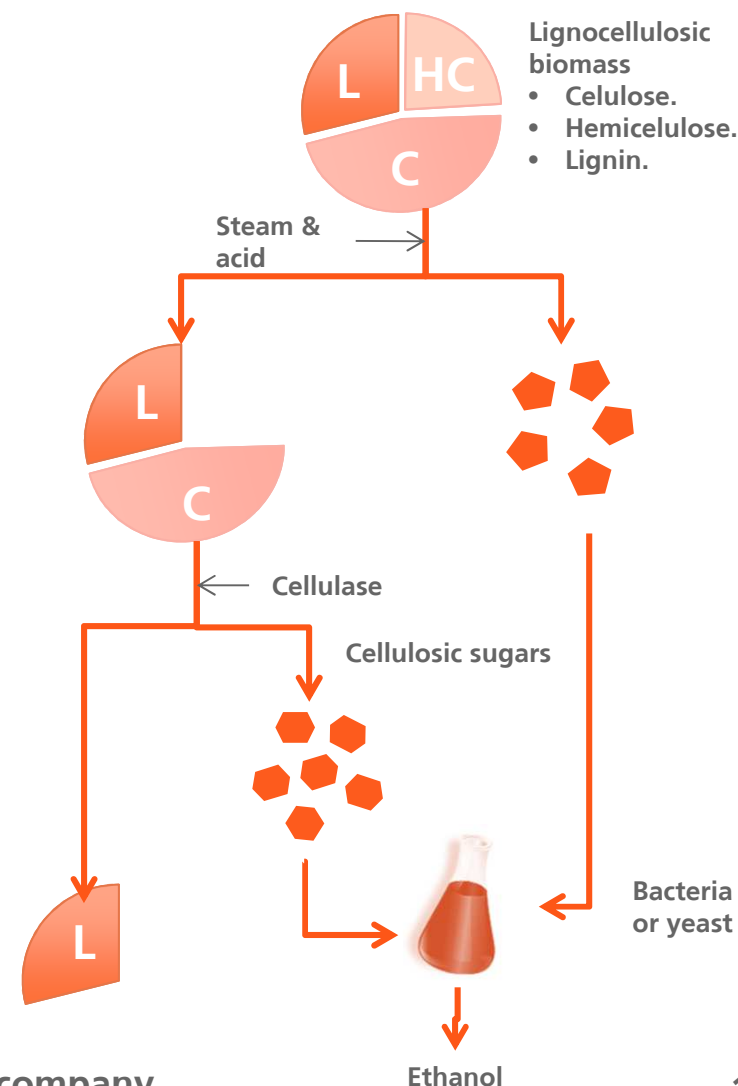
- Alternative to the traditional production from cereals and sugar beet.
- Un-lock the potential for the biofuel production.

Advantages

- Possibility to use a higher raw material range of lower cost and not linked to the food market.
- Lower production costs in comparison with first generation conversion technologies.
- Higher environmental sustainability.

The global biotech ethanol company.

Enzymatic hydrolysis technology

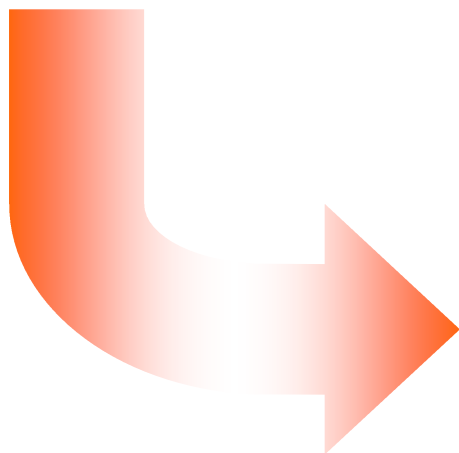


ABENGOA BIOENERGY

Innovative technology solutions for sustainability

Biochemical pathway

Enzymatic hydrolysis development roadmap



- Internal research and evaluation of options, capabilities, potential markets, ...
- Develop of a research team based on scientists and engineers.
- Develop of a set of collaborators:
 - Companies.
 - Research Centers.
- Evaluation and definition of an investment stage gate.

The global biotech ethanol company.

ABENGOA BIOENERGY

Innovative technology solutions for sustainability

Biochemical pathway

Enzymatic hydrolysis development roadmap

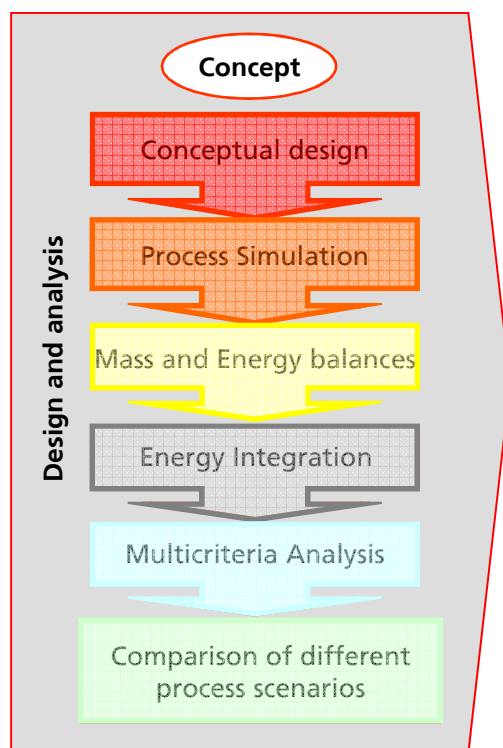
Preliminary investigation

Detailed investigation

Development

Validation

Commercial launch



- Process development.
- Technologies evaluation.
- Basic operations development.
- Collateral technologies evaluation.
- Investment on knowledge and technology development:
 - Spanish government support: Cenit Projects.

The global biotech ethanol company.

ABENGOA BIOENERGY

Innovative technology solutions for sustainability

Biochemical pathway

Enzymatic hydrolysis development roadmap

Preliminary investigation

Detailed investigation

Development

Validation

Commercial launch



- Pilot facility at York (US).
- Process configurations testing.
- Basic operations testing.
- Coproducts valorization research.
- Investment on testing and technology development:
 - DOE support.

The global biotech ethanol company.

ABENGOA BIOENERGY

Innovative technology solutions for sustainability

Biochemical pathway

Enzymatic hydrolysis development roadmap

Preliminary investigation

Detailed investigation

Development

Validation

Commercial launch



- Demo facility at Babilafuente (Spain).
- Process evaluation.
- Yield optimization testing.
- Collateral technologies testing.
- Coproducts valorization research.
- Economical evaluation.
- Bottle necks identification and overlapping.
- Investment on testing and technology demonstration:
 - EC FP5 support.
 - Spanish government support.

The global biotech ethanol company.

ABENGOA BIOENERGY

Innovative technology solutions for sustainability

Biochemical pathway

Enzymatic hydrolysis development roadmap

Preliminary investigation

Detailed investigation

Development

Validation

Commercial launch



The global biotech ethanol company.

- Economical project evaluation.
- Financing requirements.
- Engineering development.
- Special equipment purchasing.
- Raw material acquisition and logistic plan.
- External support required:
 - Eu VII FP support: Led project.
 - DOE Hugoton project support.
- ABBK
 - Capacity: 25MGal.
 - Cogeneration: 20MW.
 - Feedstock: Agricultural Residues.

Biochemical pathway

Enzymatic hydrolysis. Innovation required

Status

R&D

Biomass pretreatment

- ✓ Development of steam explosion technology.
- ✓ Performance studies to reduce severity.

Biomass fractionation

- ✓ Fractionation technology implemented in York Plant.
- ✓ Analysis of performance and optimization.

Enzyme production

- ✓ Development of an enzyme mixture at competitive cost in €/l ethanol.
- ✓ External collaborations intended to increase the enzymatic cocktail efficiency.

C5 fermentation

- ✓ Fermentation optimization and engineered microbial systems for high yield and productivity and low inhibition.

Valorization of biomass fractions

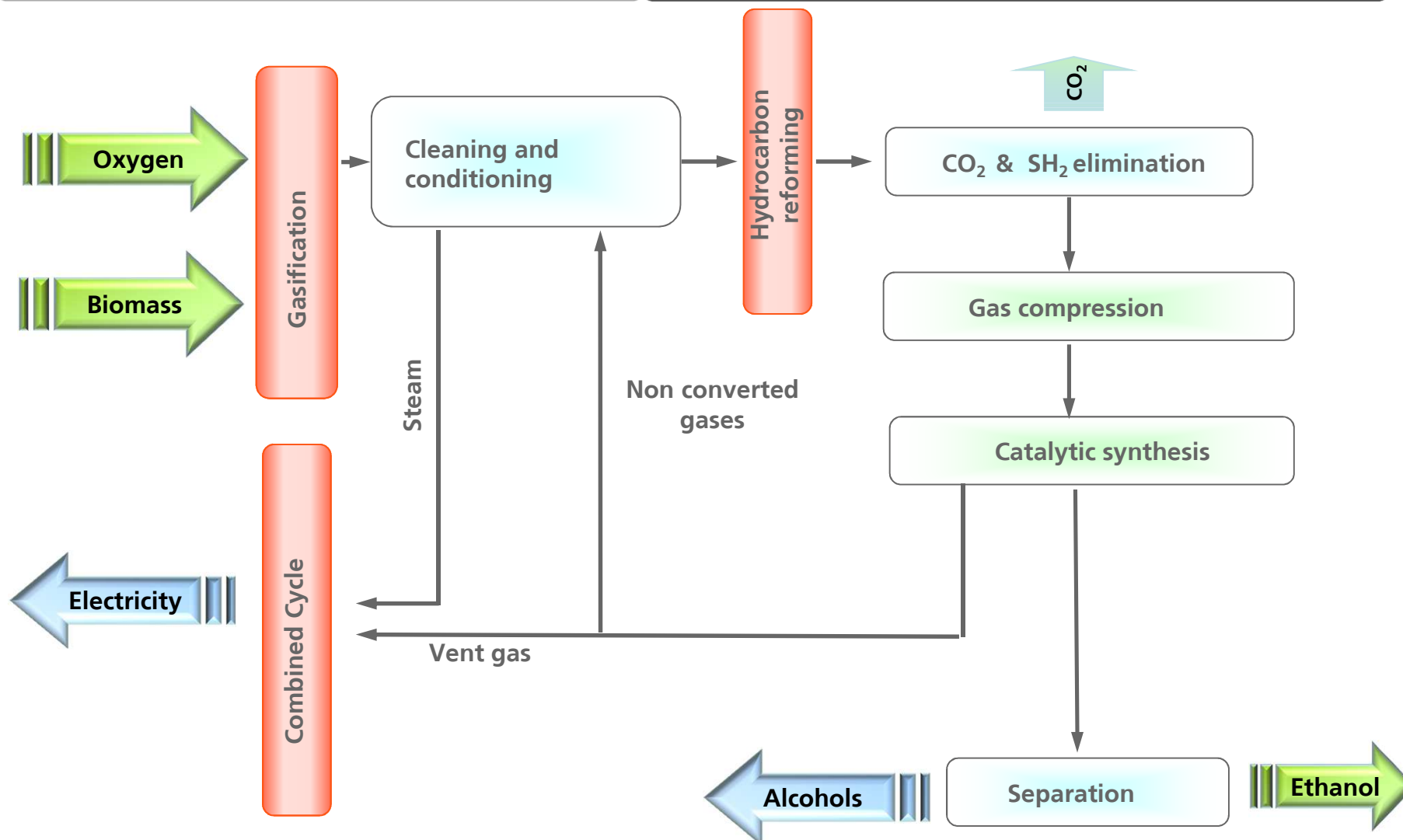
- ✓ Participation in IP Biosynergy.
- ✓ Contact with potential partners within the chemical sector.

ABENGOA BIOENERGY

Innovative technology solutions for sustainability

Thermochemical pathway

Process

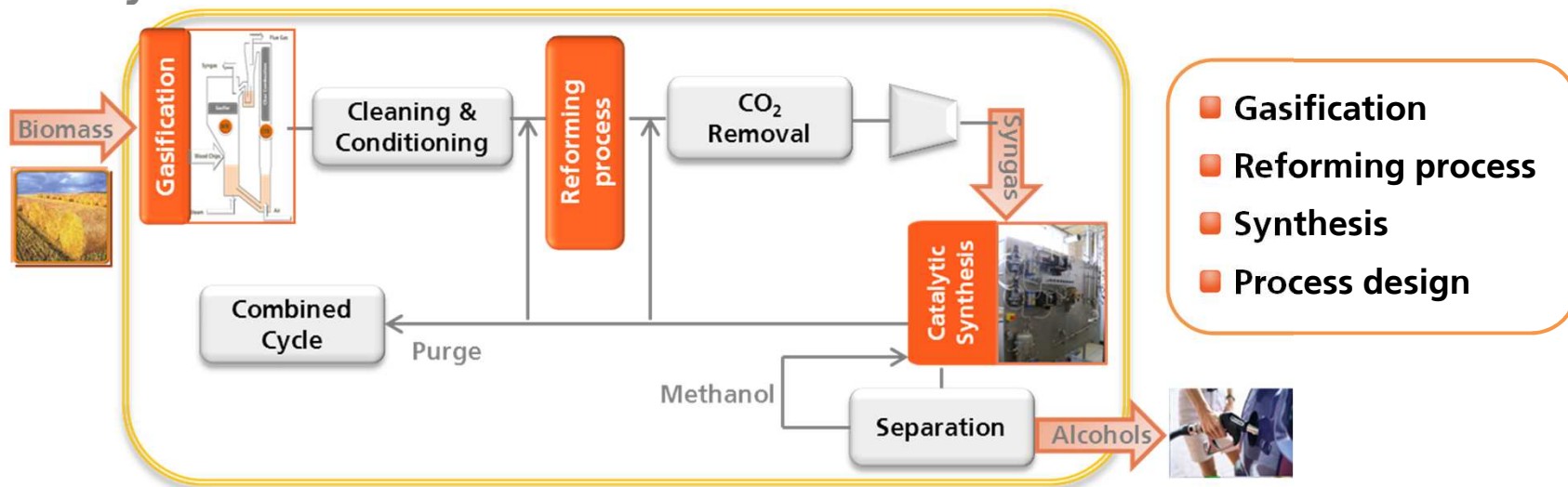


The global biotech ethanol company.

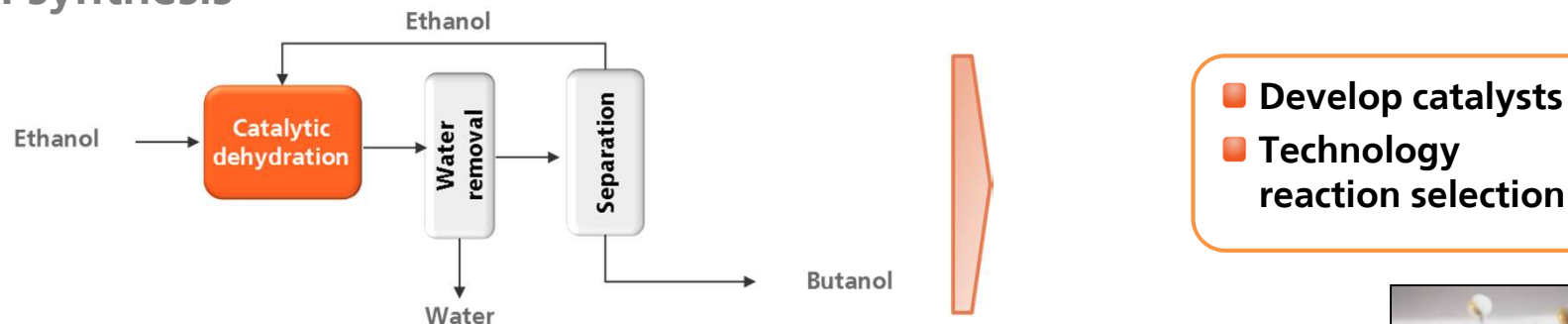
Thermochemical pathway

Research program

Ethanol synthesis



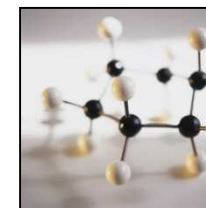
BuOH synthesis



New products

- Develop catalytic bio-product from sugars or ethanol

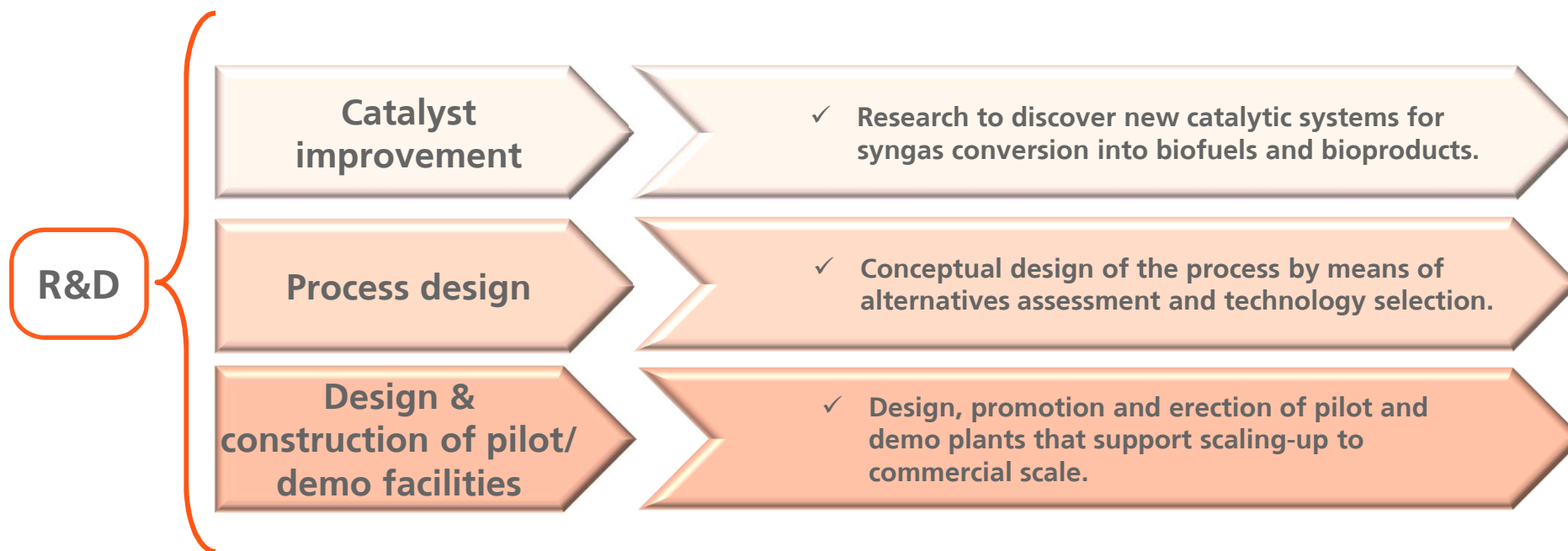
The global biotech ethanol company.



Thermochemical pathway

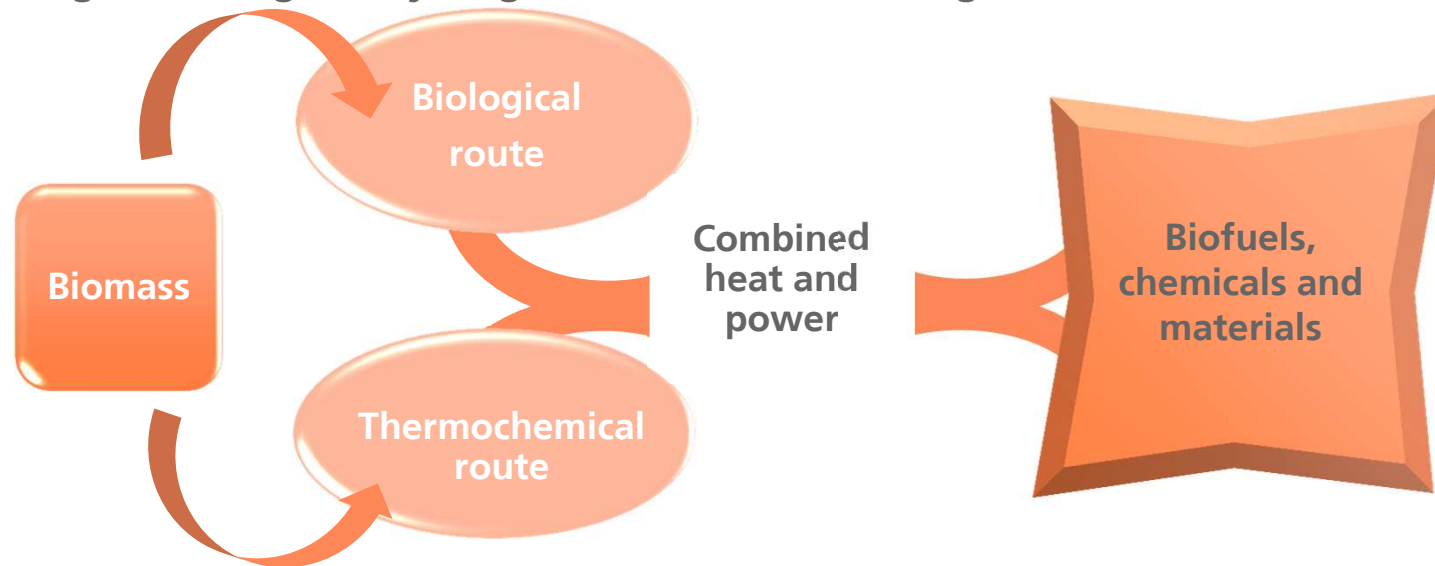
Gasification and catalytic synthesis

Status



Biorefinery concept

- Biorefinery is understood as a further stage in the development of technologies based on biomass as feedstock.
- Optimal combination of biological, thermo-chemical, and chemical processes:
 - Aimed to produce a complete range of products.
 - Using a wide range of feedstock.
 - Getting advantage of synergies between technologies.



ABENGOA BIOENERGY

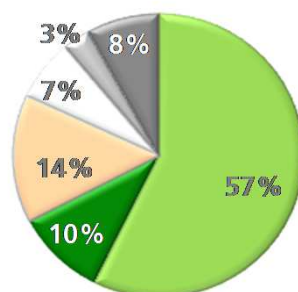
Resulting in a strong diversified company

Ebitda Margin	
Volatility/Uncertainty	
Products	Biodiesel
	Feed
	Sugar
	Electricity
	Bioproducts
	Adv. Ethanol
	Conv. Ethanol
Target Market	

Now

10 % – 15 %

Medium / High



Ethanol-focused



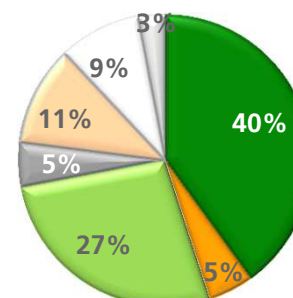
26 BGY

The global biotech ethanol company.

2020

15 % – 20 %

Low / Medium



Incorporated biomaterials

Plastics, Fibers,
Rubber & other
Polymers

Hydrocarbon
Fuels



PMMA
Market size
739 BGY



Polyesters/
Xylene/Styrene
27BGY



Poly-
Propylenes
32 BGY



Rubber, Lubricants
& Additives
8 BGY



Gasoline
349 BGY



Diesel
484 BGY



Jet
94 BGY

994 BGY

ABENGOA BIOENERGY

1. Abengoa

2. Abengoa Bioenergy

3. Second generation biofuels

4. Conclusions

3. Conclusions

- **Lignocellulosic biomass** is able to improve biofuels production capacity .
- Technologies based on lignocellulosic biomass are considered as **advanced processes** to increase the number of products and raw materials, as well as to optimize the use of biomass.
- There are two main different technologies: **biochemical** (enzymatic hydrolysis) and **thermochemical** (catalytic synthesis).
- Abengoa Bioenergy is erecting a **first-of-its-kind cellulosic ethanol facility** based on enzymatic hydrolysis technology.
- **Thermochemical pathway:**
 - Partial demonstration status for biomass gasification.
 - Critical term: ethanol synthesis, gas cleaning.
 - Process integration in pilot stage and further demonstration are critical.
- Both biological and thermochemical pathways can be included into a common process (**biorefineries**) that allows a maximal use and optimization of biomass to produce a **complete range of biofuels and bioproducts**.

Questions



Carmen Millan Chacartegui
Abengoa Bioenergy New Technologies
carmen.millan@bioenergy.abengoa.com