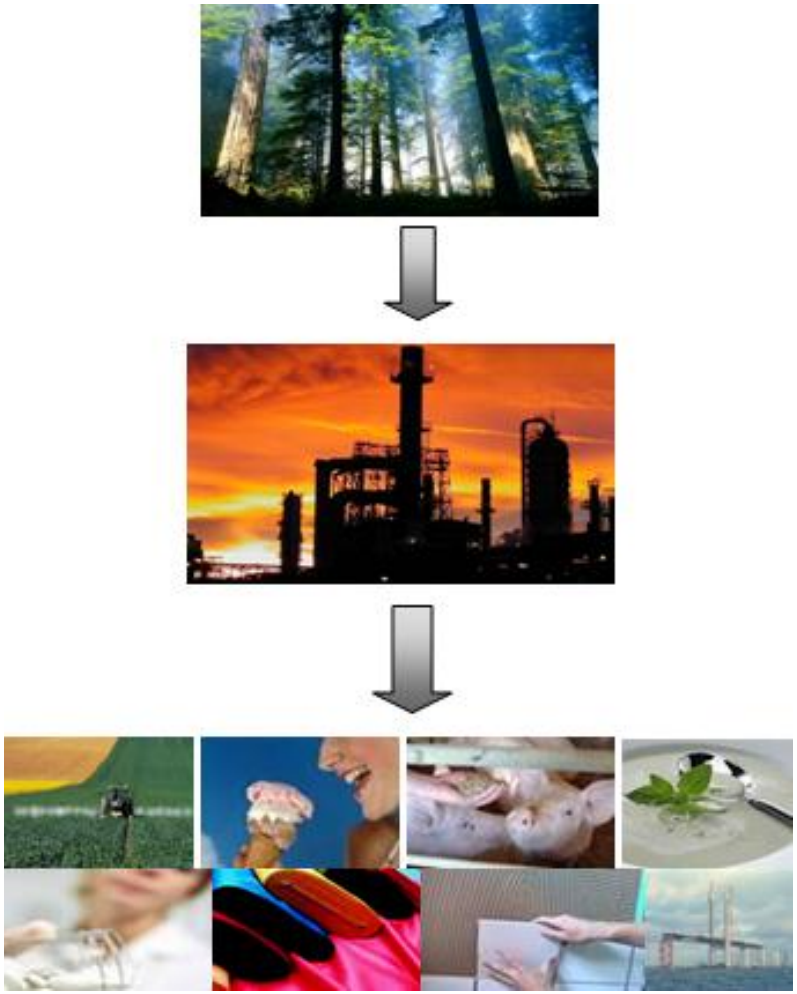


Klimautfordringen skaper muligheter for trebasert prosessindustri i Norge

Gisle L Johansen
Senior Vice President R&D and NBD
gisle.l.johansen@borregaard.com

Prosin 2011
Kristiansand 25.05.2011

Borregaard
The Sustainable Biorefinery

Green business?
The value chain should tell the story

Raw Material

Natural
Renewable
Non toxic

Processes

Reduced emissions
Energy conservation/renewable energy
High raw material utilisation
Risk management

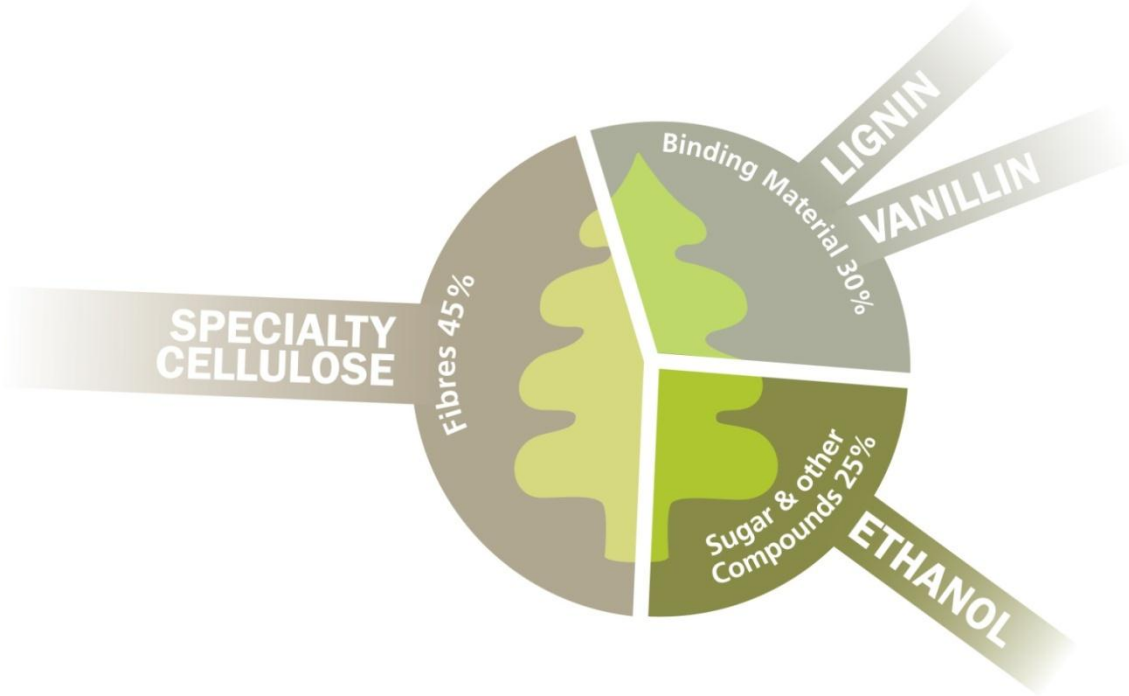
Products

High performance
Substitutes oil based products

Borregaard

Biorefinery – a Business Model Based on Biomass

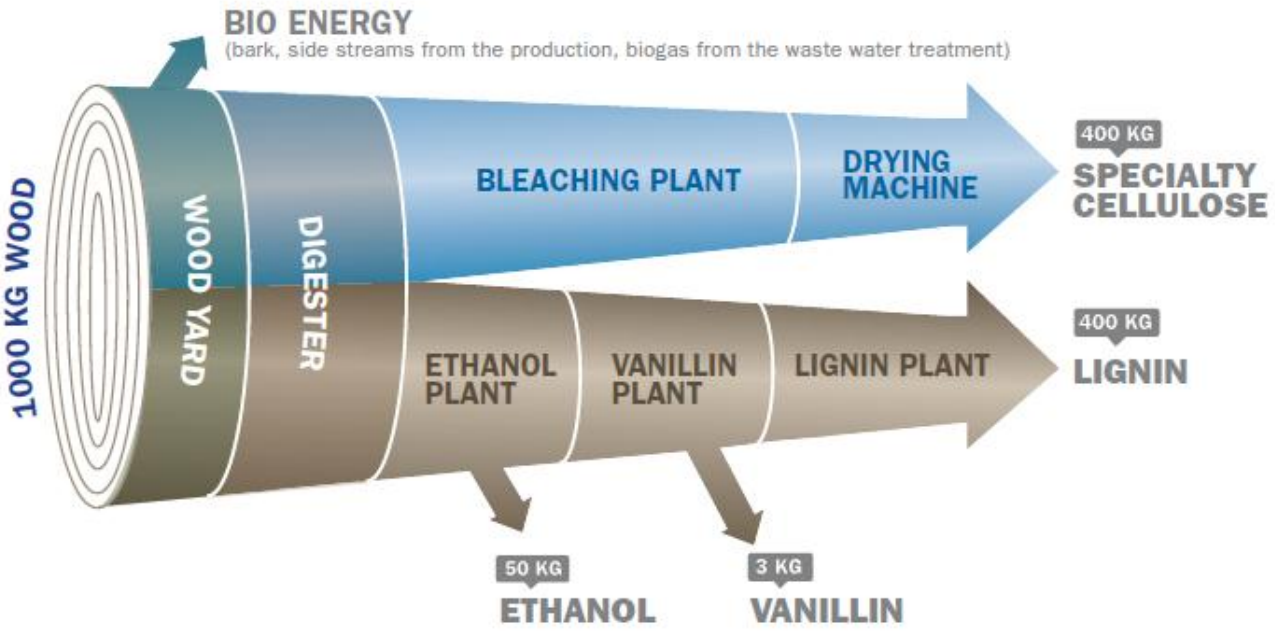
Borregaard's biochemicals are sustainable and environmentally friendly substitutes to petrochemicals



Borregaard is a global leader in bio based chemicals.
Strong innovation efforts increase the value added to our customers.

Borregaard

Wood Based Chemicals in an Integrated Concept



- Leading supplier of specialty **cellulose**
- Global leader in **lignin** performance chemicals, 50%+ market share
- Only producer of **vanillin** from lignocellulosics
- Production of lignocellulosic **bioethanol** since 1938 (20.000 m^3/y)

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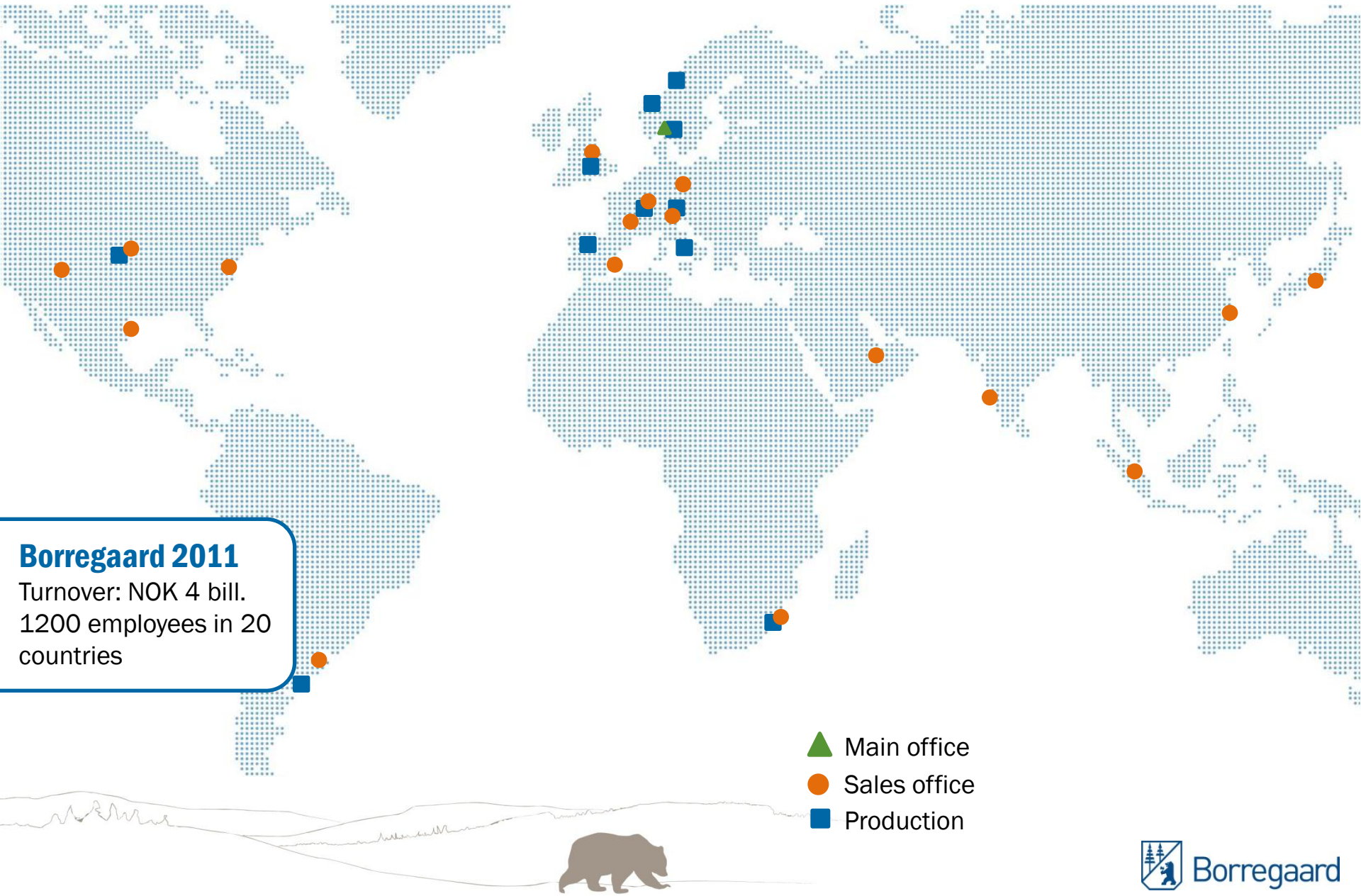
Global presence



Borregaard 2011
Turnover: NOK 4 bill.
1200 employees in 20 countries

Borregaard

Borregaard Site in Sarpsborg, Norway

Head office - R&D - Production
800 employees, 2200 mill NOK turnover

Specialty cellulose, lignin products, biovanillin, 2G bioethanol

Basic chemicals, energy, pharmaceutical intermediates

Organization for Innovation

New cellulose based materials

- Innovation – involving the whole organization
  - Top management focus
  - Innovation Management Teams
- More than 25% of Borregaard's revenues from new products
- R&D Centre with 60 employees, 25 PhD's
- R&D spending EUR 13 million/year

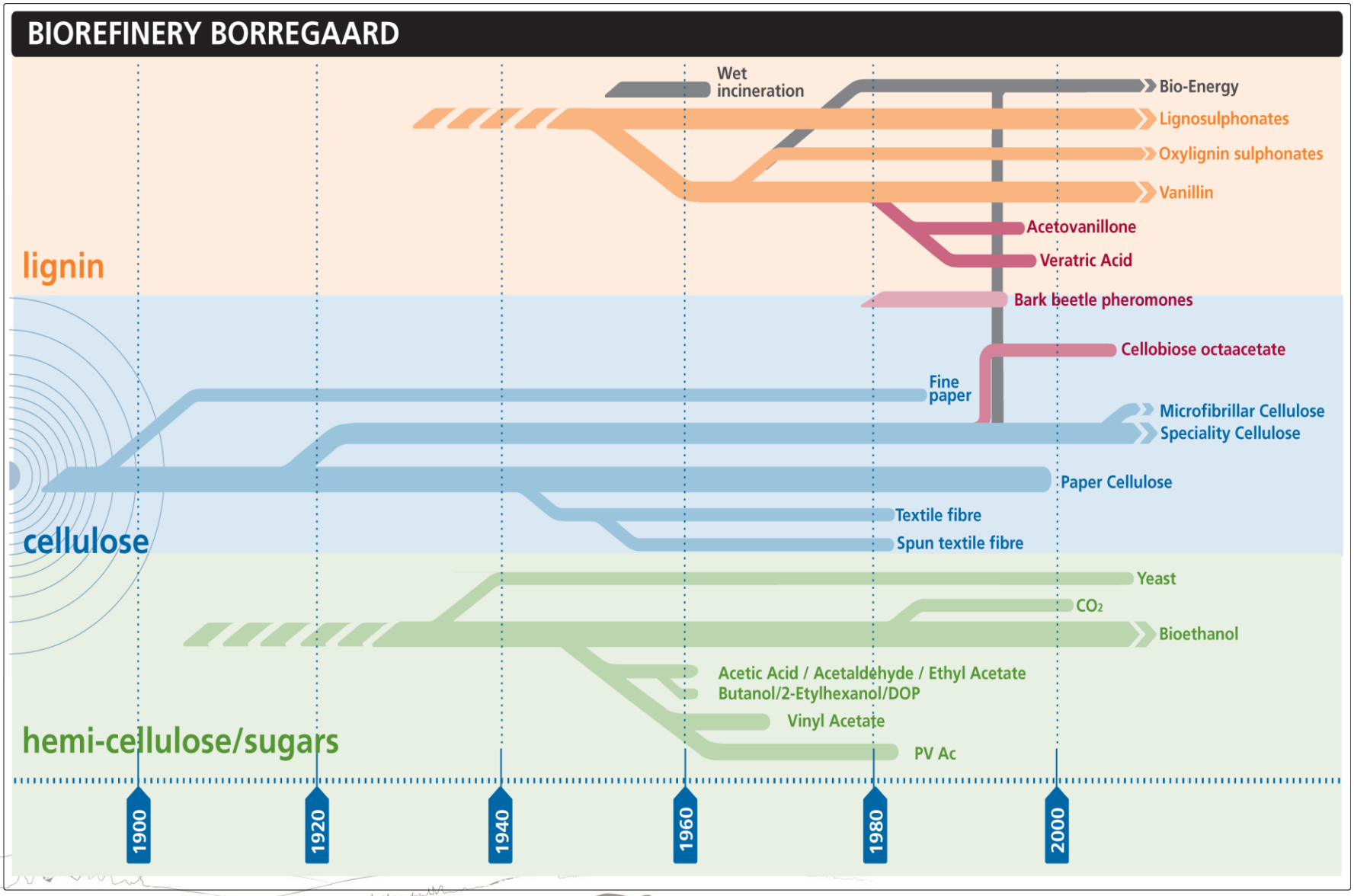
Environmentally friendly products to the agro sector

Patent application for new process for 2G bioethanol

Development of new processes within EHS

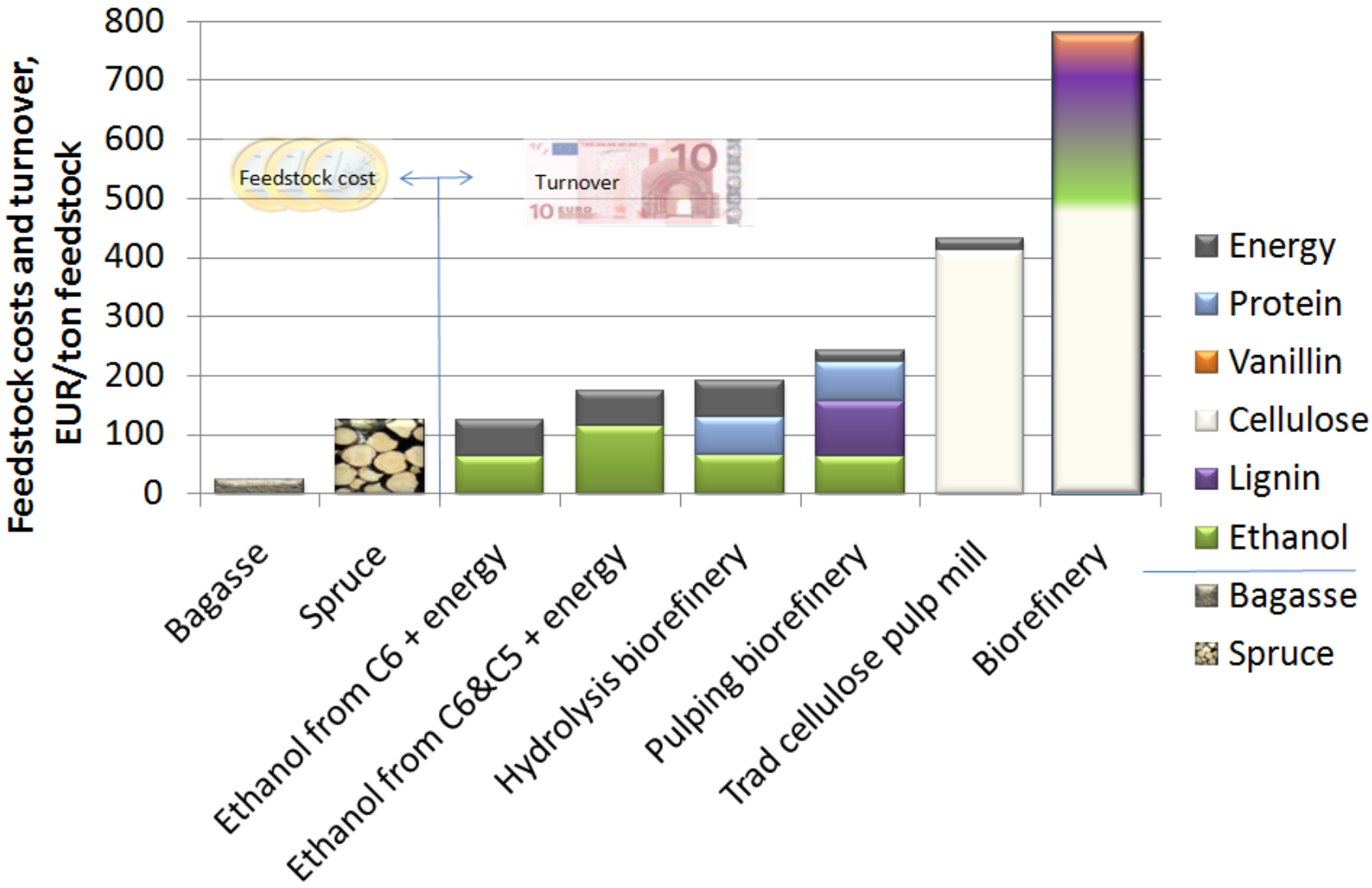
Utilisation of "new" biobased raw materials

From Papermill to Biorefinery



Borregaard

Turnover for Biorefineries



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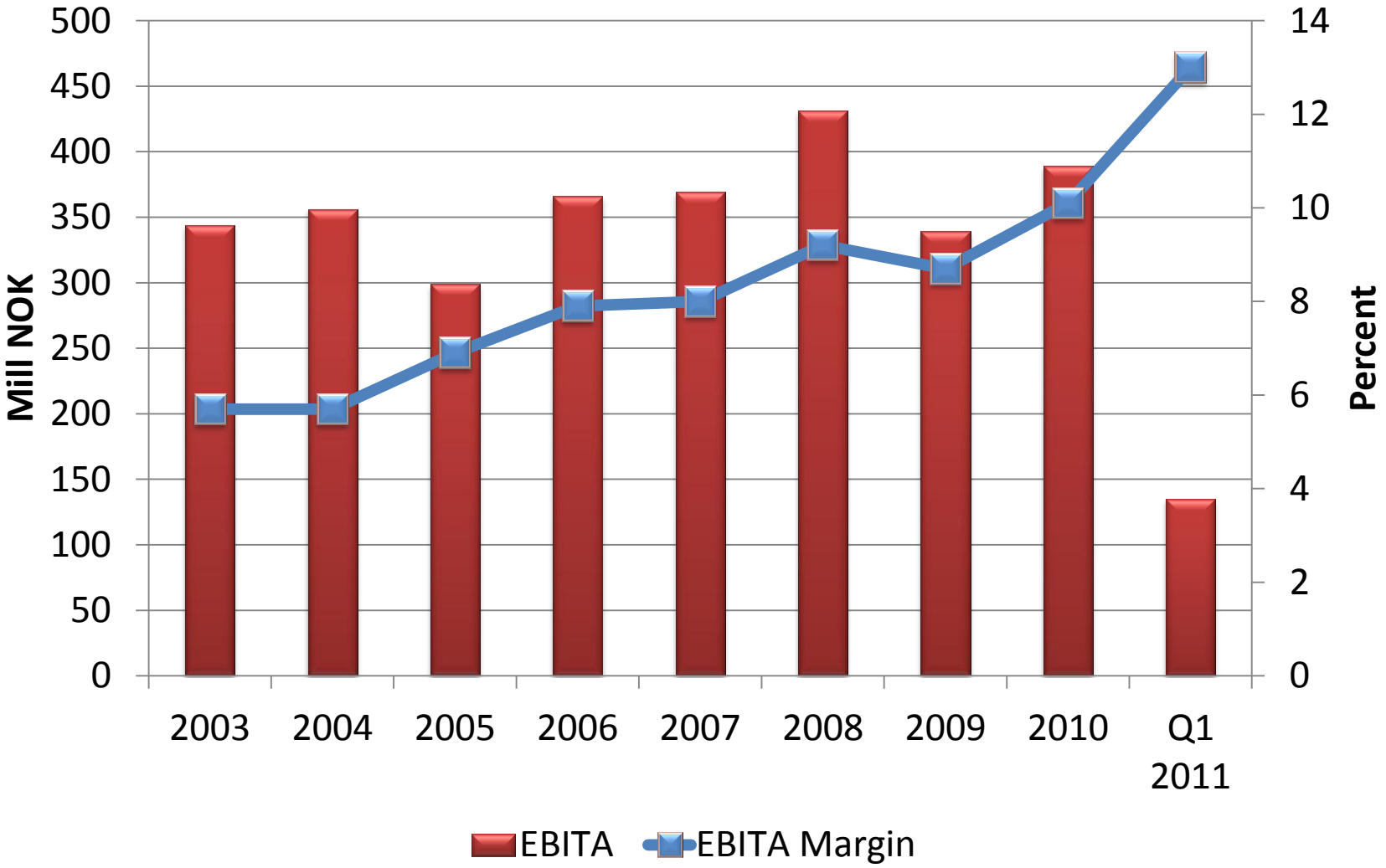
Life Cycle Analysis ”From Cradle to Gate”

Borregaard product	Reference product	Effect of replacing with biorefinery products
Cellulose	Cellulose from cotton	+
Ethanol	Ethanol from ethylene Bio ethanol from sugar cane	+ +
Lignin	Super plasticizer	+
Vanillin	Vanillin from guaiacol	+

The reference products have a substantially higher emission of greenhouse gasses

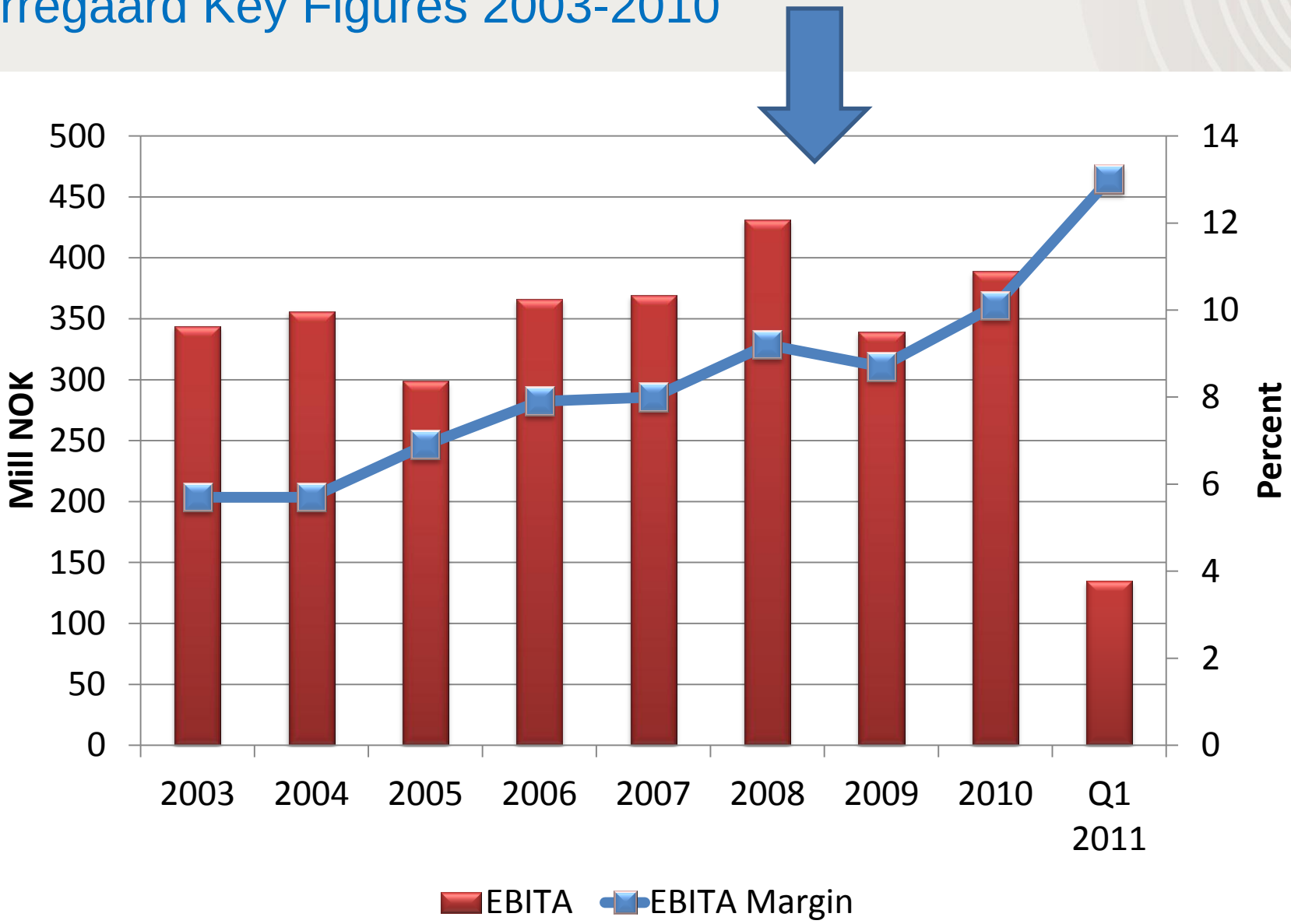
Borregaard

Borregaard Key Figures 2003-2010



Borregaard

Borregaard Key Figures 2003-2010



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Oil or Biomass – “Green” or “Black” Carbon?

GREEN CARBON

Sustainable chemicals, materials, ingredients, biofuel

BLACK CARBON

Borregaard

Biorefinery Options - Profit Considerations

High

Cost/price

Low

BIOREFINERY

BioMaterials
- *Polymers*
- *Composites*

BioChemicals
- *Flavours*
- *Monomers*
- *Proteins*
- *Fine chemicals*
- *Speciality chemicals*

BioFuel
- *Bioethanol*
- *Biodiesel*
- *Biogas*

BioEnergy
- *Electricity/Heat*
- *Liquid Fuels*
- *Pellets*

High

Creating values

Low

Borregaard

Biorefinery Options - Profit Considerations

High

Cost/price

Low

BIOR ERY

Preferred combination

BioMaterials
- *Polymers*
- *Composites*

BioChemicals
- *Flavours*
- *Monomers*
- *Proteins*
- *Fine chemicals*
- *Speciality chemicals*

BioFuel
- *Bioethanol*
- *Biodiesel*
- *Biogas*

BioEnergy
- *Electricity/Heat*
- *Liquid Fuels*
- *Pellets*

High

Creating values

Low

Borregaard

Biorefinery Options - the Incentive Paradox in Europe

High

Cost/price

Low

Political Incentives

Preferred co ation

BIOR Y

BioMaterials
- *Polymers*
- *Composites*

BioChemicals
- *Flavours*
- *Monomers*
- *Proteins*
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BioFuel
- *Bioethanol*
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BioEnergy
- *Electricity/Heat*
- *Liquid Fuels*
- *Pellets*

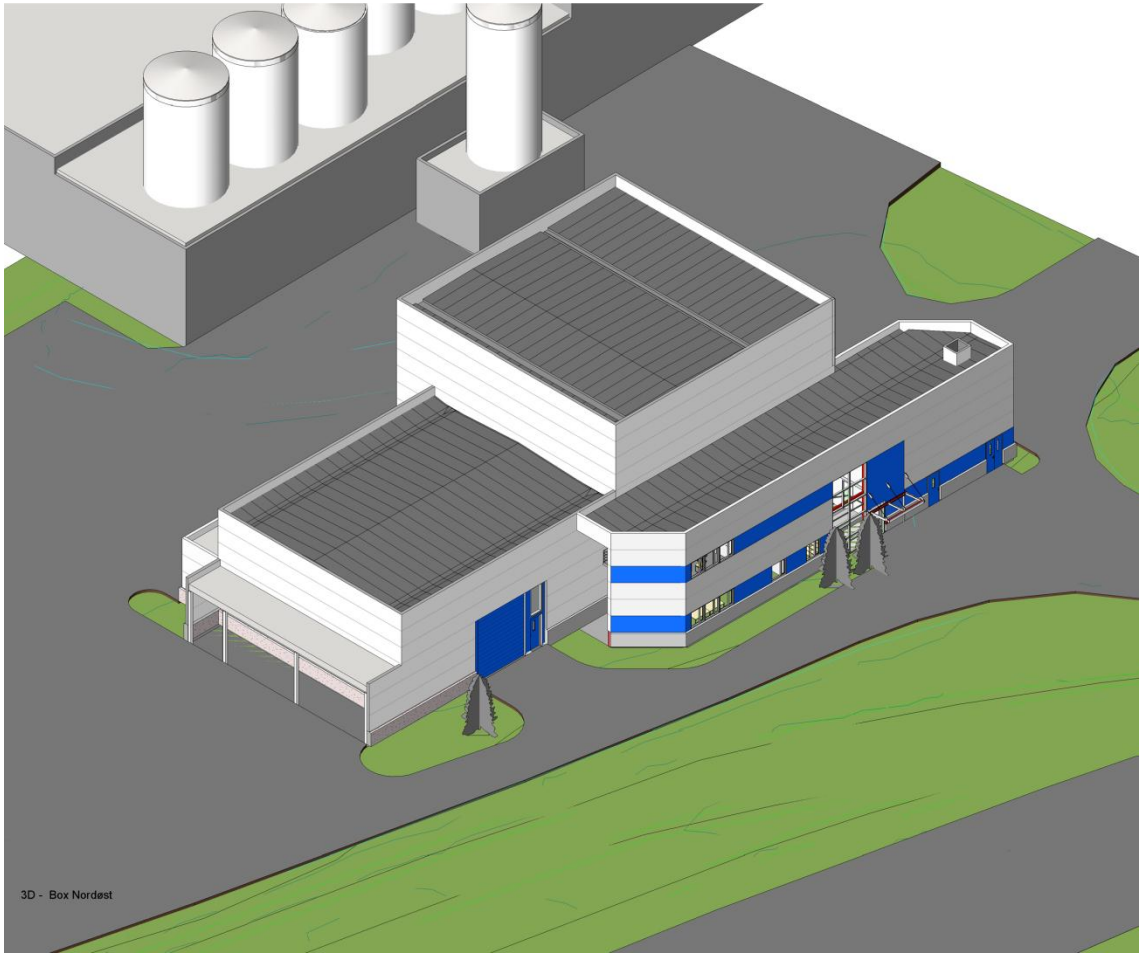
High

Creating values

Low

Borregaard

Pilot Plant: Ethanol and Biobased Chemicals



BALI

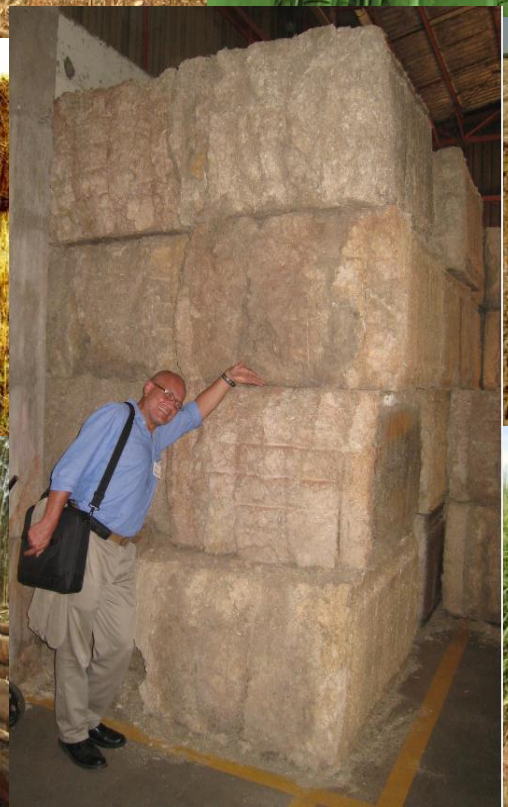
Bioethanol **Lignin**

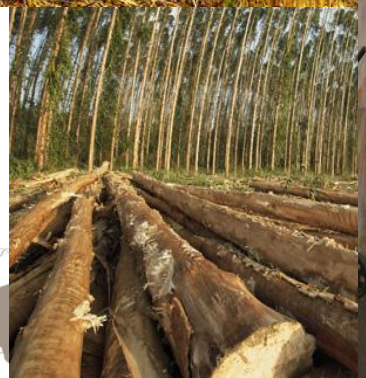
Borregaard

Feedstock

- Potential feedstocks
  - Agricultural waste
  - Bamboo
  - Various wood species
  - Energy crops
- Our research so far focused on
  - Bagasse
  - Spruce
  - Eucalyptus
  - Wheat straw
  - Willow






BALI Process in a Nutshell

Bagasse

Pretreated and ”reactive” pulp

Water soluble lignin

Borregaard

Lignin Based Chemicals – Applications

BALI Process in a Nutshell – Sugar Platform

Pretreated and ”reactive” pulp is hydrolyzed using cellulase enzymes

Hydrolyzate = monomeric sugar in solution

Fermentation of C5 and C6 sugars

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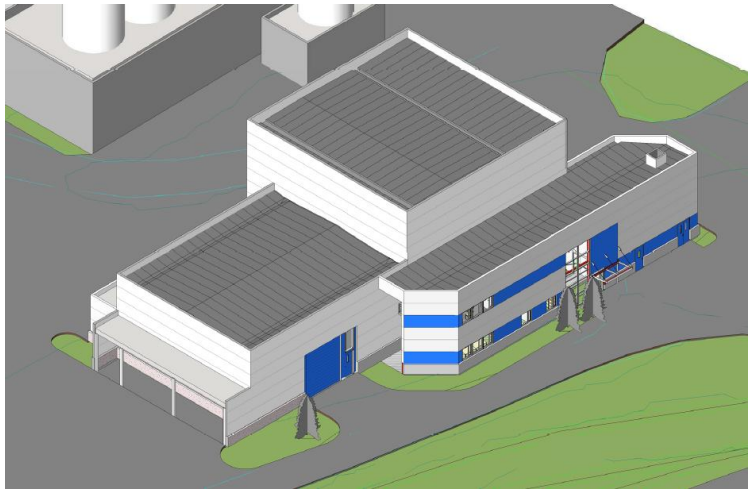
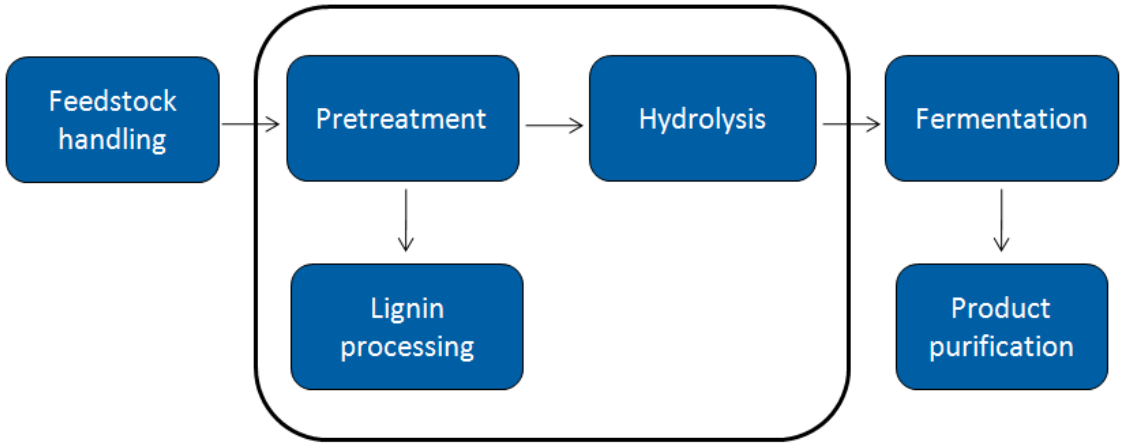
BALI Pilot Plant

- Location: Borregaard Sarpsborg, Norway
- Flexible feedstock
- 1 metric ton dry matter/day
- Break ground May 2011
- Commissioning Q2 2012
- 800 m^2 total area
- Budget cost: EUR 15 mill





Borregaard

Borregaard is a partner in
2 out of 3 EU biorefinery projects

Borregaard

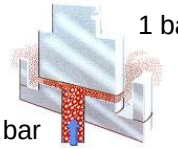
PowerFiber

Product Characteristics

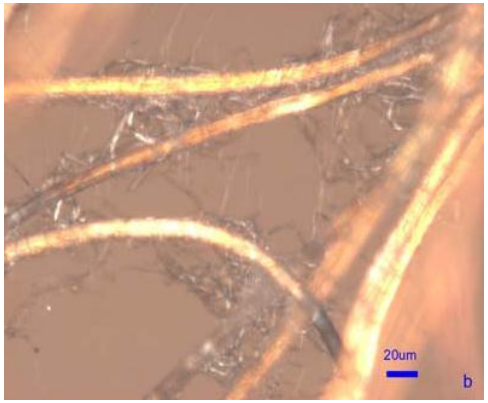
Standard Fibers

Length: 2-3 mm
Width : 20-60 µm
Aspect ratio: ⇨ 150
Small surface area

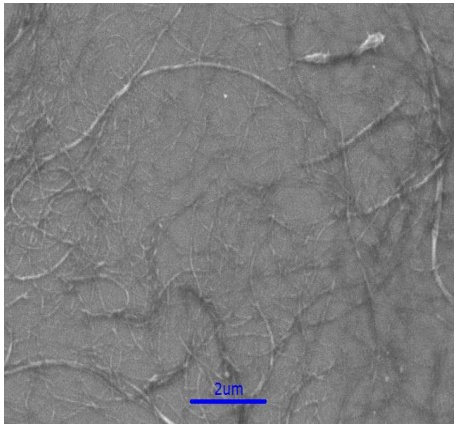
High Shear Processing



De-fibrillation



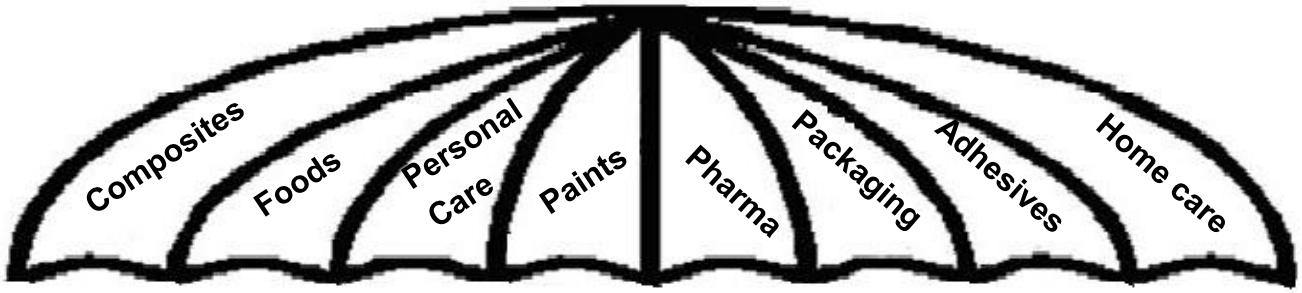
PowerFiber

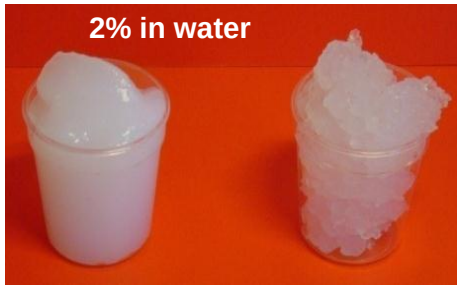


Length: up to 100 µm
Width : 10-100 nm
Aspect ratio: ⇨ 10 000
Large surface area

PowerFiber

Unique properties





suprabio
innovative bio solutions

Borregaard

The role of governments in developing industries and climate solutions

Most important:

Long term, stable framework conditions that stimulates industry and technology development in wanted direction by providing:

- Improved competence infrastructure
  - Better schools – more focus on science
- Support the whole innovation value chain

  Increased support to R&D projects with commercial/environmental potential

  Support pilot /demo plant – phase
- Improved physical infrastructure
  - Logistics often a big part of industry costs
- Financial incentives
  - Incentives must be long term and support a development in wanted direction
- Be a good example
  - Buy environmentally friendly products
  - Ambitious targets

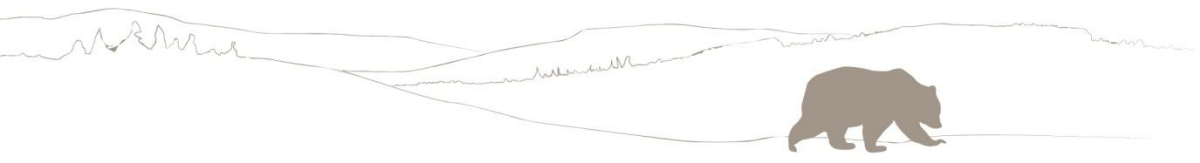
Borregaard

Funding

- EuroBioRef
  - Borregaard granted EUR 3.0 mill funding (2010 – 2013)
  - BALI pretreatment & enzymatic hydrolysis

- Biomass2Products – B2P
  - Borregaard granted 2,3 mill EUR from the Norwegian Research Council (2009 – 2012)

- BALI·PILOT
  - Borregaard granted EUR 7,3 mill from Innovation Norway (2011-2012)
  - Covering 45% of investment costs



Borregaard