The BALI Project

Borregaard Background
Project Summary

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Business Development
Borregaard LignoTech

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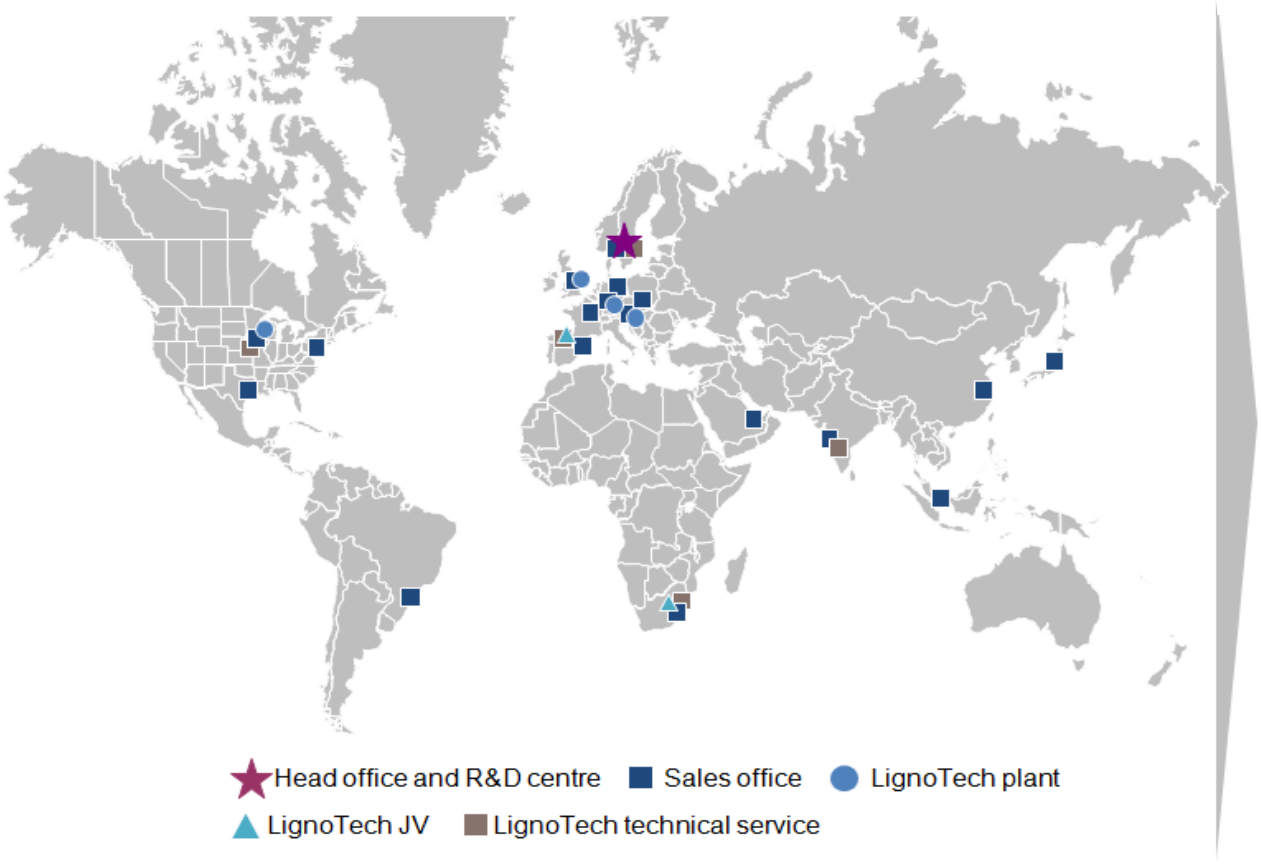
Global presence

An international business with global customers

Production facilities and sales offices in 17 countries provide a global platform



BAS is an international bio-refinery company headquartered in Norway and the global leader in lignin based bio-chemicals.

Lignin based bio-chemicals are replacing oil based chemicals in a broad range of application areas.

BAS is the largest producer of ethanol from wood. 6 mill g/y.

Annual sales $750MM USD

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Borregaard then and now

Edward Partington

Karl August Kellner

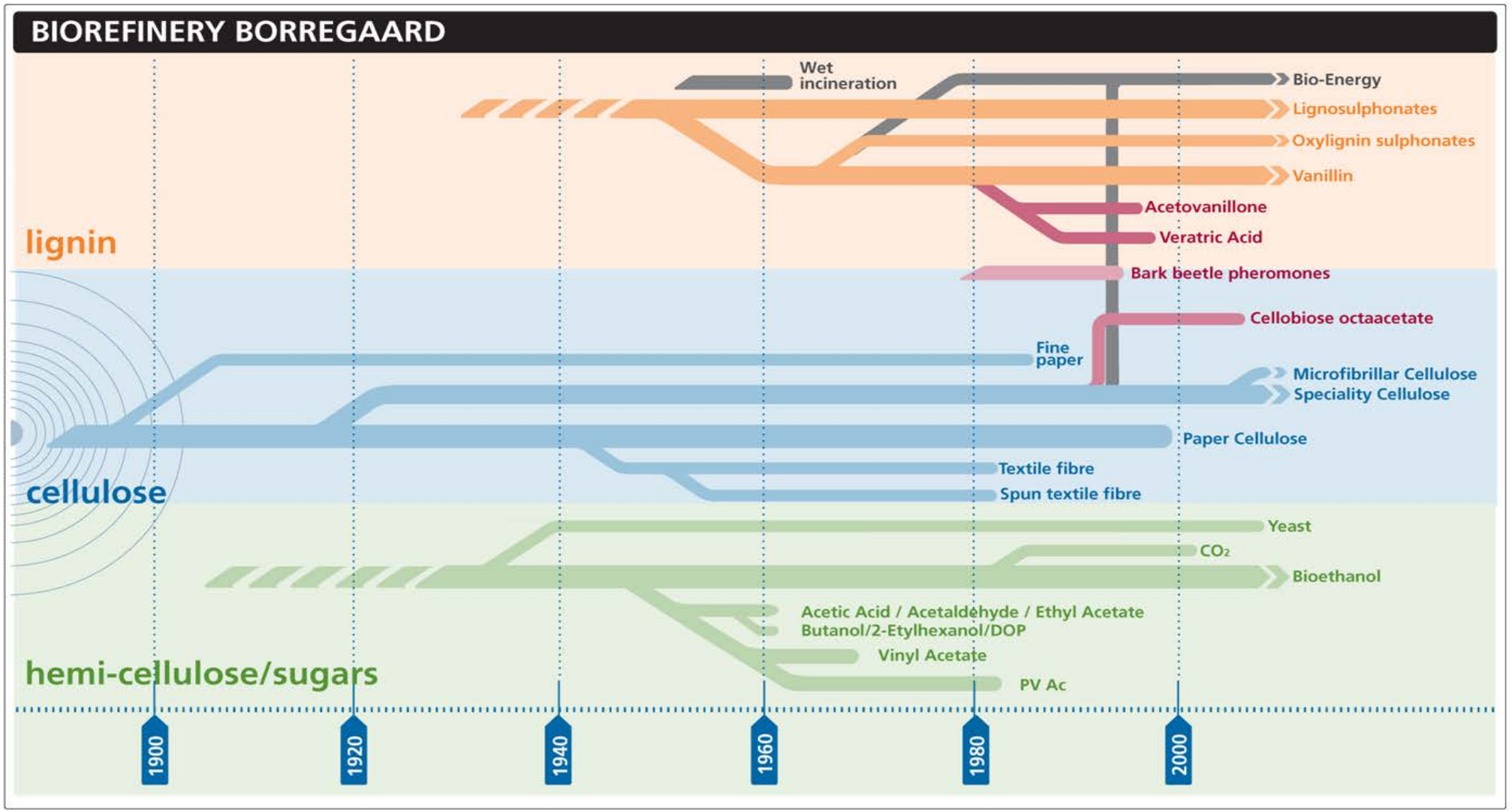
- Competitive edge in 1889
  - cheap timber
  - cheap energy
  - cheap labor

- Austrian technology
- British capital

- High cost
  - raw materials
  - energy
  - labor

- Competitive edge in 2012
  - technology
  - market
  - innovation pipeline

From paper mill to biorefinery



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R&D center in Norway – key figures and core competence

Number of employees	80
Number of MSc	12
Number of PhD	28
Pilot/demo plant personnel	20
Average experience (years)	10
Female employees (%)	40
Average age	41

Organic chemistry	13
Wood chemistry	9
Biopolymer chemistry	6
Physical chemistry	3
Analytical chemistry	2
Microbiology	4
Process technology	3

- Flexible, experienced and competent
- Unique and strong competence platform
- Attractive working environment
- Specialists and generalists
- Benefitting from each others' core competences

Lignin Chemicals – the driver for BALI™

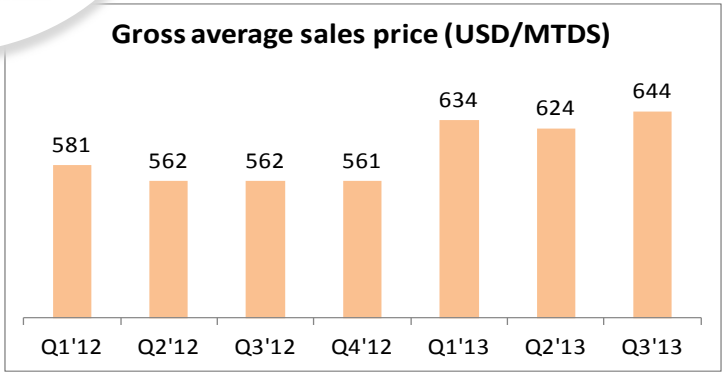
- Largest supplier with a global footprint
- Unique technical and application expertise
- A sustainable and versatile product portfolio
- Large, diverse and stable customer base
- Strong R&D in new applications
  - Technical staff approximately 100

Construction

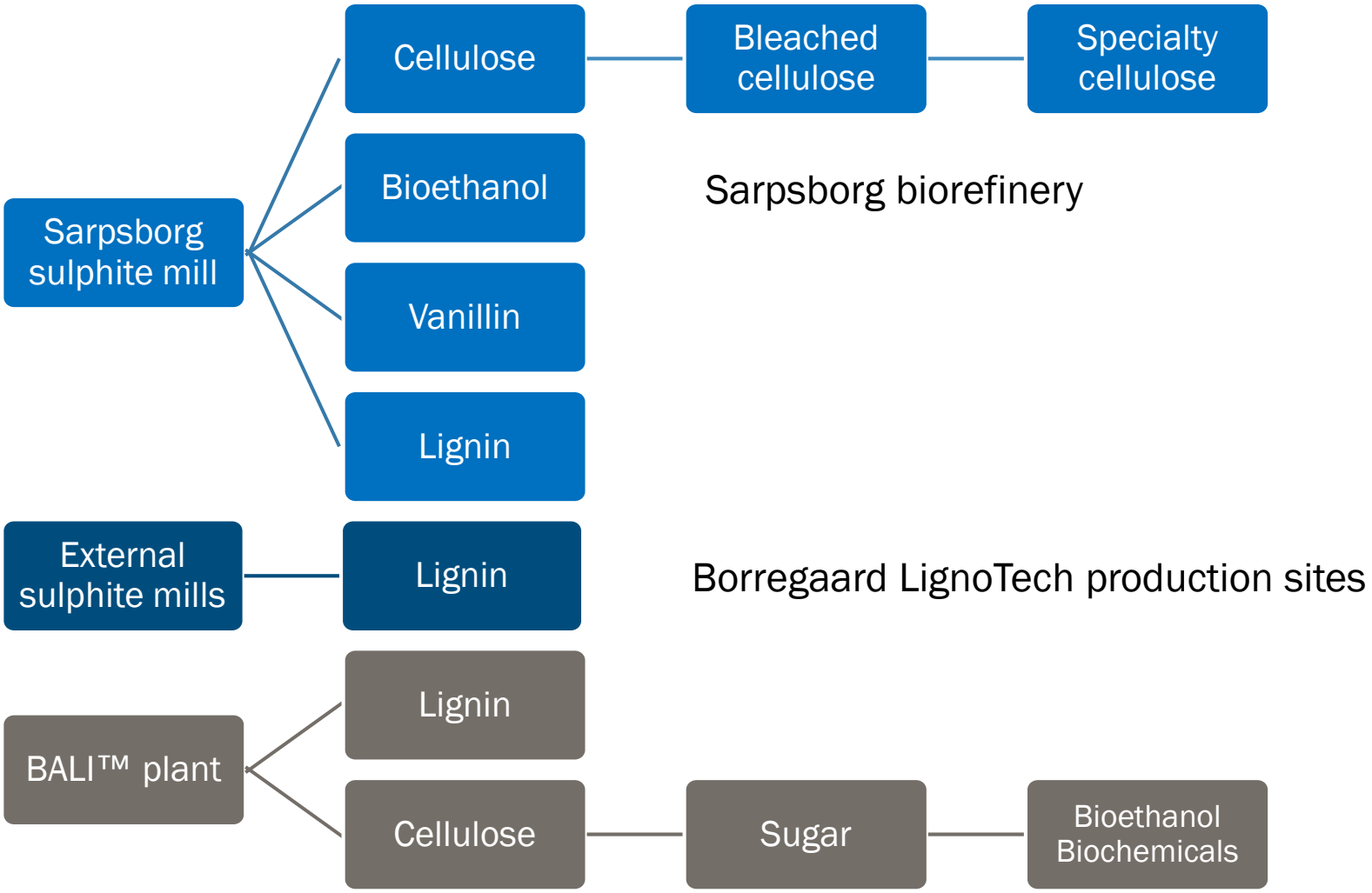
Agriculture

Automotive

Mining



Borregaard value chains



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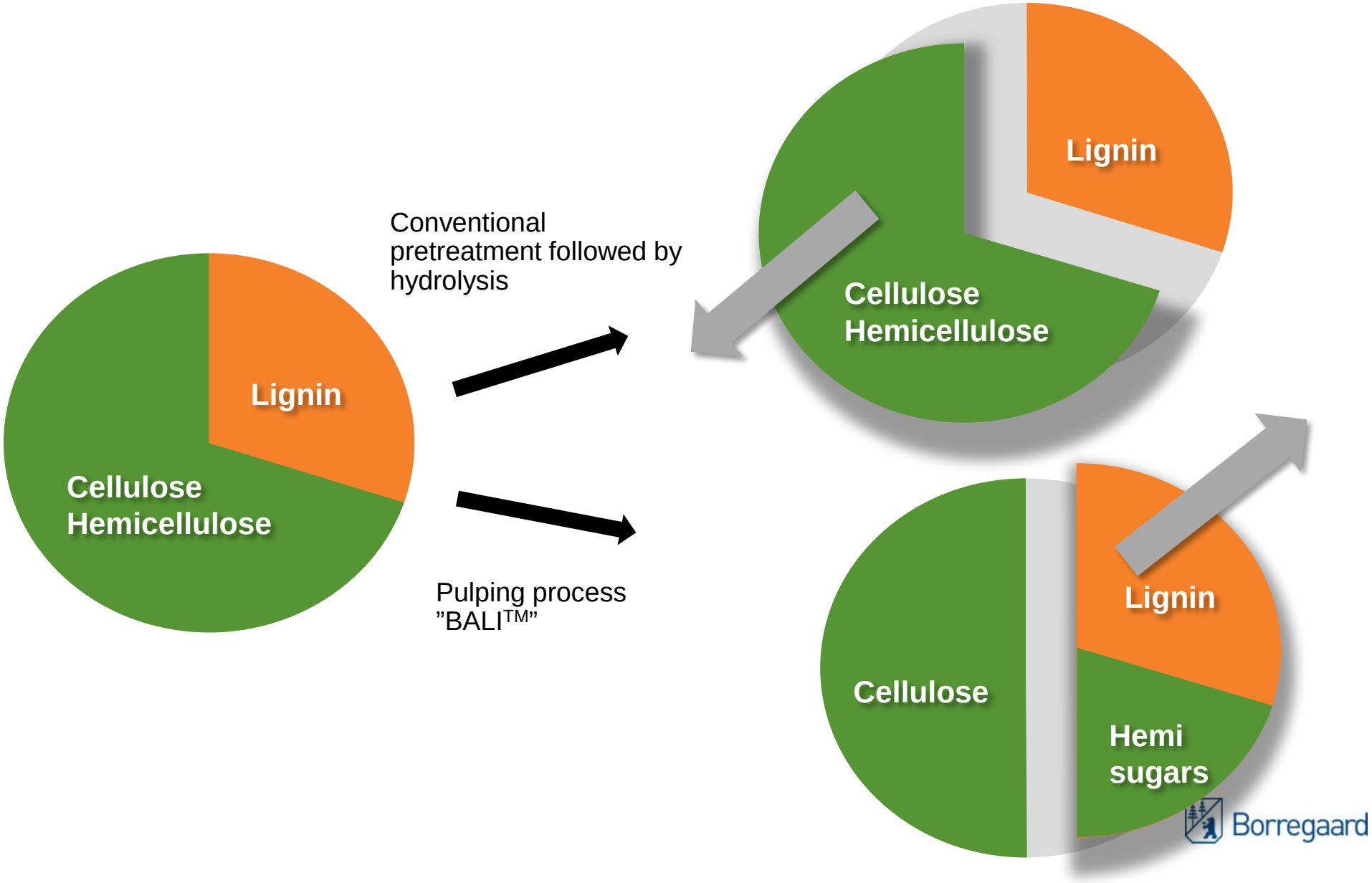
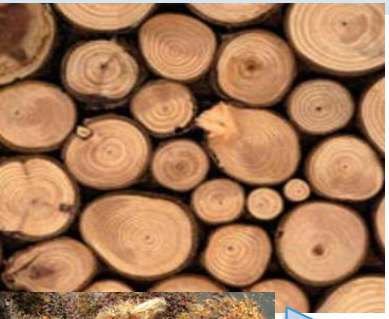
What is dissolved during pretreatment?



BALI™: Possible 1st Plant Pathway



- Softwood/Bagasse

BALI

- Sugars
- Lignin

- Cellulosic Ethanol
- Sale

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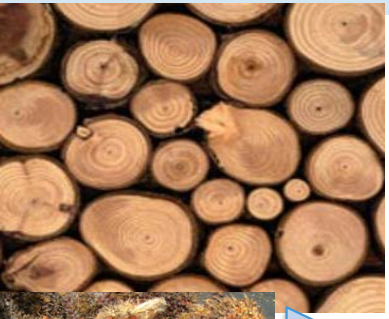
BALI™: A biorefinery technology platform



- Biomass

Sugars

BALI

Lignin

- Sale
- **Cellulosic Ethanol**
- Drop-in Fuel
- Biochemicals

- **Sale**
- Combustion
- Gasification /conversion

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BALI™ produces clean hydrolysates

- BALI™ hydrolysates are easily fermentable to ethanol, indicating the absence of fermentation inhibitors

- Company A (chemical process):
  - ***”Borregaard hydrolysates were converted very efficiently”***

- Company B (fermentation process):
  - ***”Results for conversion of the acid and neutral hydrolysates are the best we have ever observed”***

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Pretreated bagasse with 75% water

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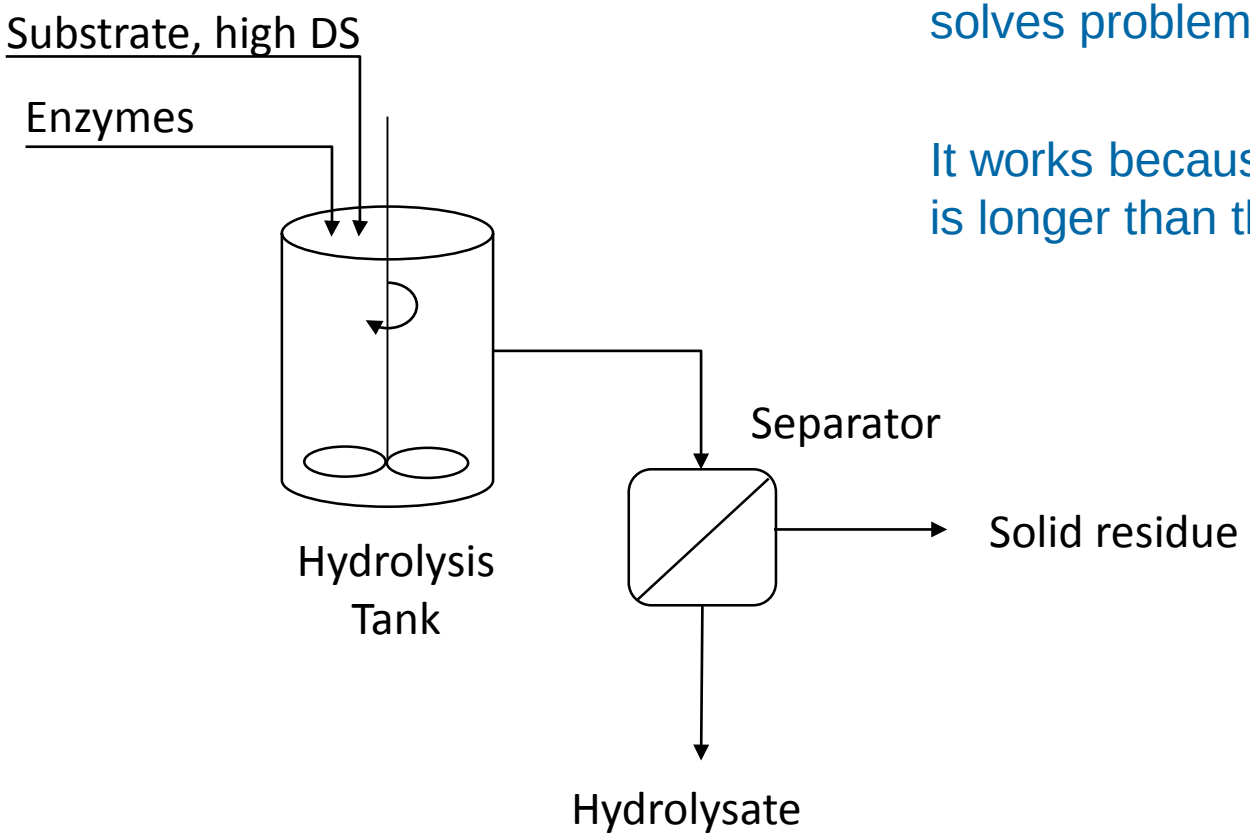
The solution: continuous enzymatic hydrolysis



Borregaard's BALI™ hydrolysis process solves problems related to high solids loading

It works because the average residence time is longer than the liquefaction time

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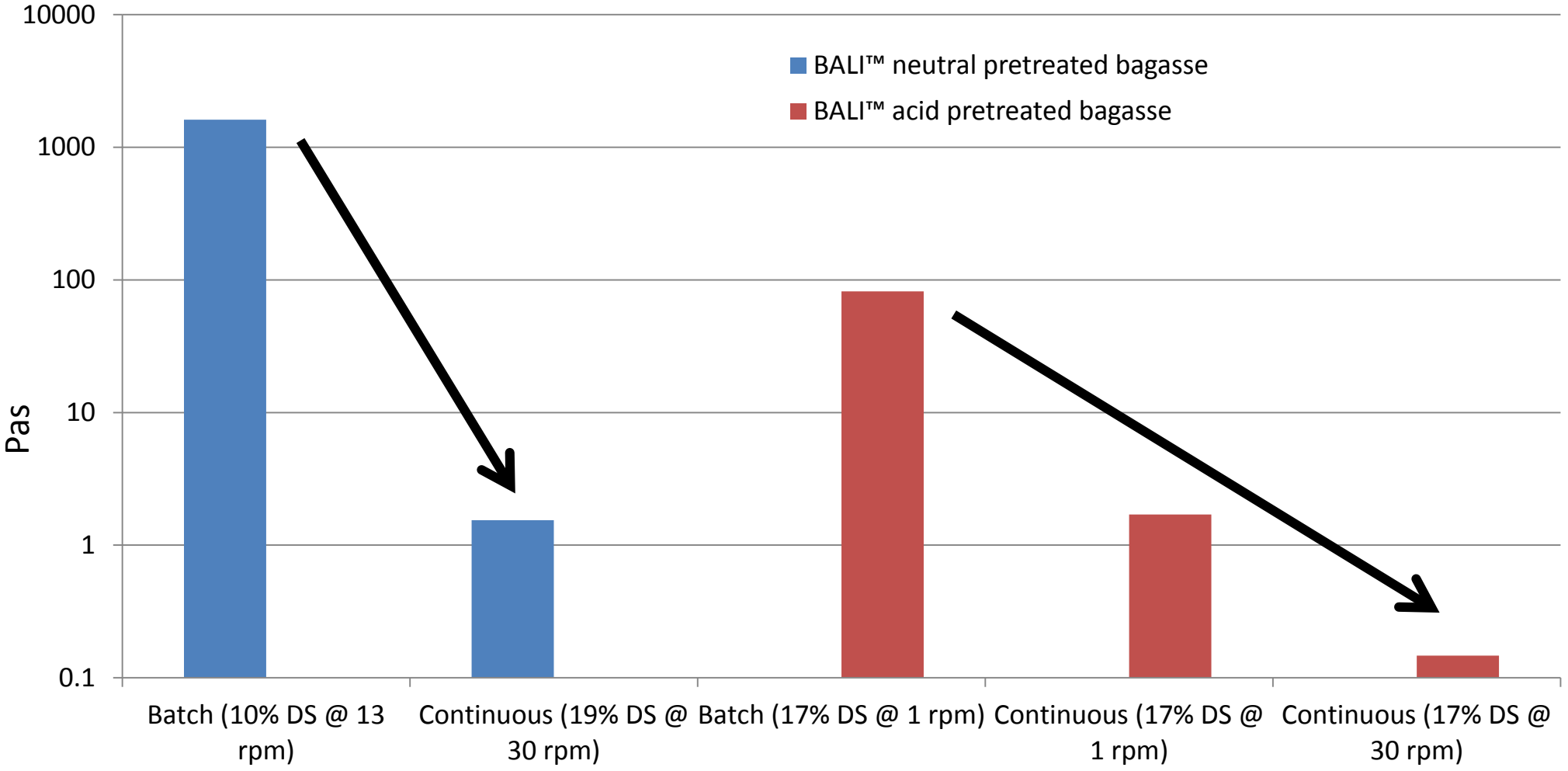
Significantly reduced viscosity during continuous operation



Viscosity measurements
Viscosities on a Physica MCR 101 rheometer equipped with a cup with a stirrer (FL 100/6W) operated at 50 °C.

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Scaling up the BALI concept – Biorefinery Demo

- **Demo plant commissioned January 2013**
  - 23 MM USD investment (total Capex)
  - 10 MM USD grant from Innovation Norway
- **Minimum size commercially available equipment**
- **450 mt biomass processed**
  - Softwood, hardwood and sugar cane bagasse
  - Continuous operations
- **Demonstration mission**
  - Process demonstration and optimisation
  - Product qualification

BALI Demo - Pretreatment step

Biomass feedstock

Pretreatment

Cellulose

Lignin raw material
water soluble

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BALI Demo: Enzymatic hydrolysis step

Cellulose

Enzymatic hydrolysis

Sugars

Bioethanol

Biochemicals

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BALI opportunities

- **Feedstock flexible process**
  - Low cost biomass options are enabled
  - Lignin performance and value determined by choice of feedstock
- **Significant revenues from both lignin and cellulosic sugars**
  - Only known 2nd generation bioethanol process with commercially viable lignin raw materials
- **Moderate Capex**
  - Significantly lower investment cost compared to traditional sulphite pulp mills
- **Enables lignin logistics optimization**
  - World wide lignin distribution costs may be reduced

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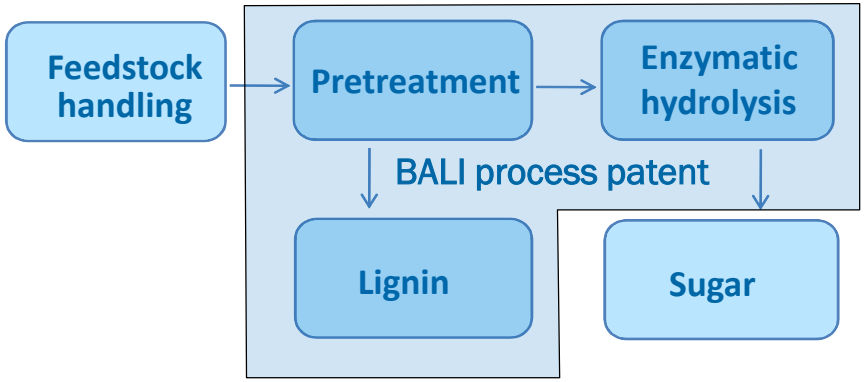
BALI – IP status

The BALI process has three layers of IP protection:

- **BALI process patents**
  - Main patent granted in Europe, pending in USA
  - Enzymatic hydrolysis of cellulose (pending)
- **Multiple lignin application patents**
- **Trade secrets**
  - Unique application and market knowledge



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Development of a business model for the first full scale BALI plant

- **Products**
  - Lignin and bioethanol
- **Biomass**
  - Softwood or bagasse
- **Partner selection criteria**
  - Local presence
  - Strategic fit – strategic interest in bioethanol or cellulosic sugars
  - Willingness to co-invest
  - Available brownfield assets
  - Process integration opportunities
- **Regional selection criteria**
  - Price and long term availability of biomass
  - Lignin market
  - Bioethanol market
  - Outbound logistics
  - Acceptable business environment

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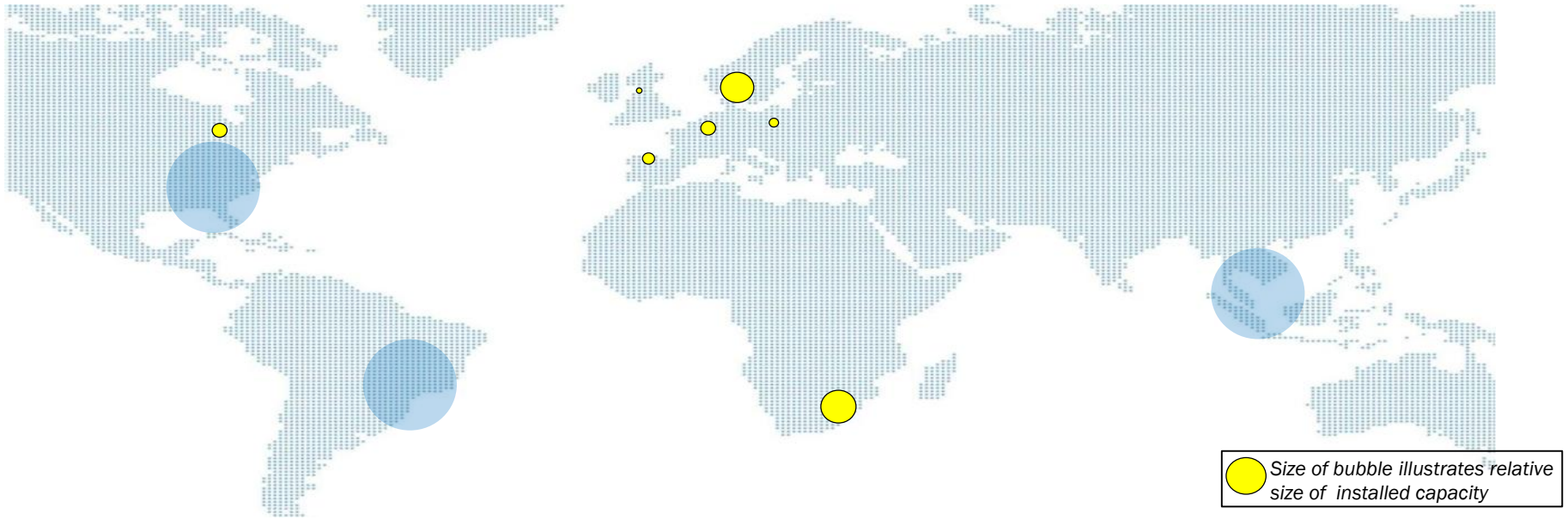
Global presence and potential areas for the first full scale plant



Partner discussions under secrecy agreements are ongoing inn all 3 regions

GO/NO GO decision and region selection late 2014

Production startup approx. 24 months after final investment decision

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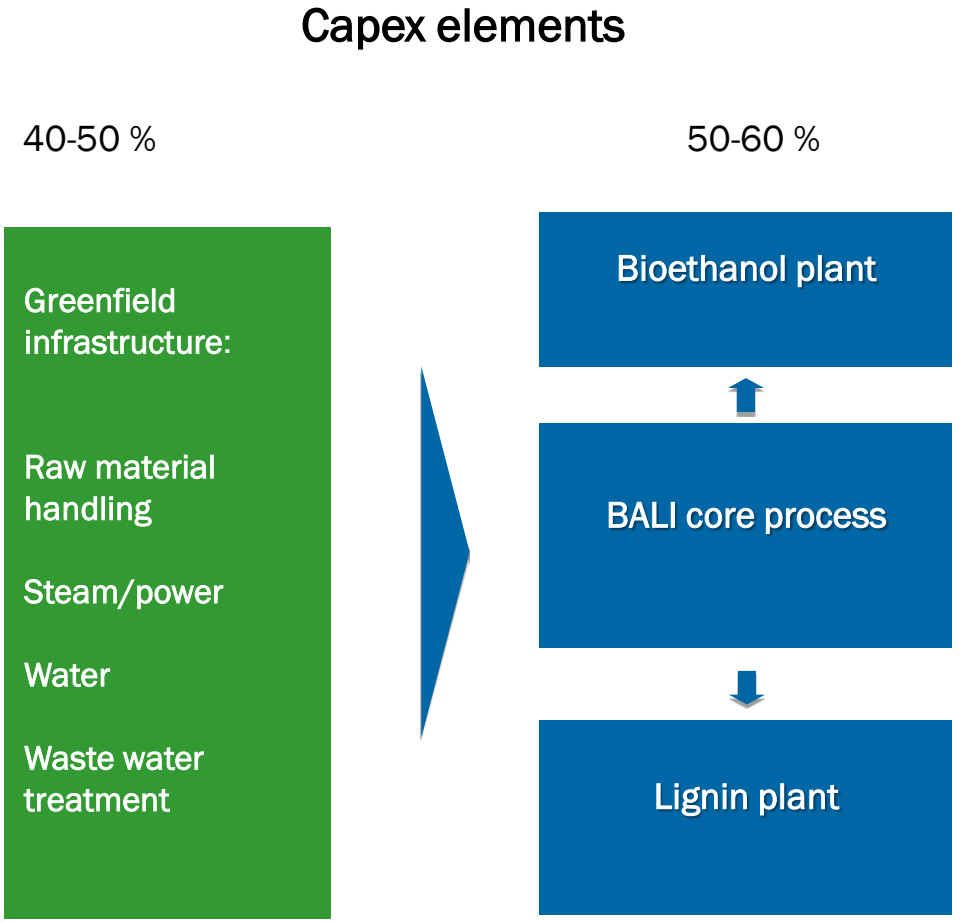
Example: Softwood based BALI plant

- **Scale assumptions**
  - 300,000 dry mt softwood
  - 140-150,000 dry mt lignin
  - 25-29 mill. gallons ethanol

- **Investment estimate USD 160-320 MM**
  - Quotes from key suppliers
  - Basic engineering
  - Trade knowledge of process
  - Potential cost reduction through site repurposing
  - Borregaard share of Capex dependent on partnership/JV structure



Conclusions

- Borregaard today
  - highly integrated wood based biorefinery

- BALI™ process
  - multifeedstock technology
  - water soluble lignin ensures good fractionation
  - continuous enzymatic hydrolysis with conventional equipment
  - demo plant running
  - profitable process

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Acknowledgements

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EuroBioRef
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Biomass2Products
3.3 MUSD from the Norwegian Research Council (2009 – 2012)

BALI pilot plant
10 MUSD for construction of pilot plant received from Innovation Norway

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The Sustainable Biorefinery