



Bioethanol from Cellulose - Technology status and Strategy for Commercialisation

Outline

- SEKAB group
- Technology status and SEKAB priorities in development of cellulose ethanol
- Integration
- Resources and networks
- Commercialisation strategy



The SEKAB Group

A leading ethanol player

- Founded in 1985 History from the forties.
- Leading European provider of renewable vehicle fuels
 - Upgrade and Distribution of ethanol fuels (42 % of Br imp)
 - Production of ethanol based Chemicals.
 - Building up part own ethanol production, EU/ Africa
 - Development of technologies for production of ethanol from cellulose.
- Among the largest European Cleantech companies
 - Employs some 170 people
 - Turnover 220 million Euro/y



Vision

Sekab should:

- Be a leader on the European market for ethanol based motor fuels and chemicals

Fuels

- E85 > 150 000 flexfuel cars
- Bioethanol for heavy duty diesel vehicles (busses) > 600 busses
- Low level bioethanol additive for gasoline, ETBE

Chemicals

- Acetaldehyde
- Acetic acid
- Ethyl acetate

20 % of annual turn around



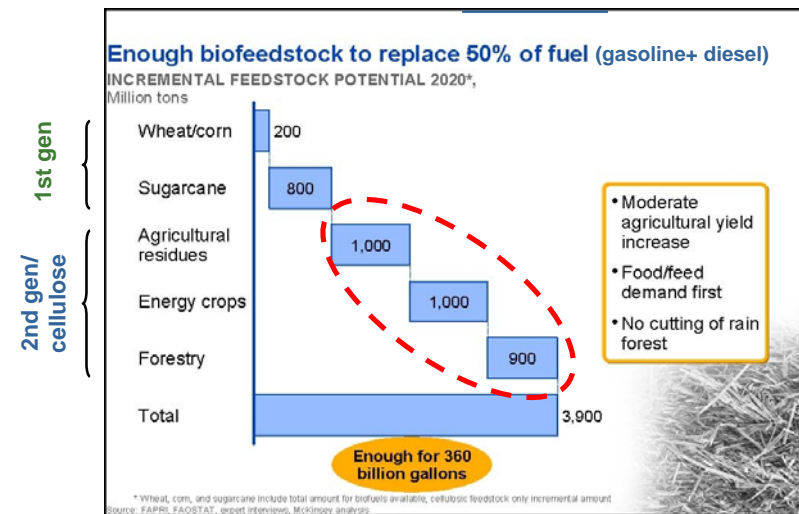
R&D

- Development and sales of new technology
- Pilotplant for bioethanol from cellulose



Why cellulose?

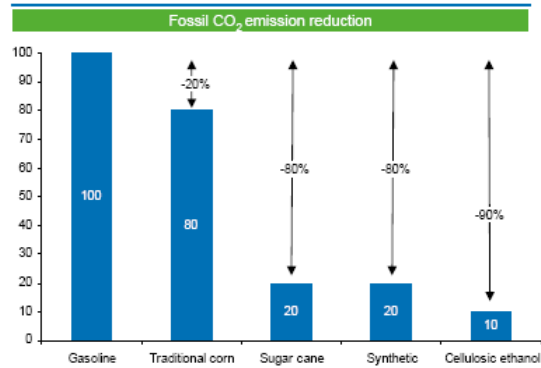
Availability of Feedstock



Mc Kinsey study, 2007

Sustainability, climate change, CO₂-emissions

Major impact on CO₂ net emissions



Cellulose feedstocks



- Swedish ethanol research programmes on wood cellulose since mid 80's
- SEKAB widening focus to bagasse since 2006

Softwood, not only in the Nordic countries!

Country	Growing stock volume, softwood. mdr m ³ forest	Growing stock volume, hardwood mdr m ³ forest
Sweden	2,2	0,4
Germany	1,9	0,9
Finland	1,5	0,3
Poland	1,4	0,4
France	1,0	1,8
Austria	0,9	0,9
Baltic countries	0,6	0,4
Czech Republic	0,6	0,1
Russia	44,6	16,2
Canada	12,8	4,6
USA	14,9	12,2

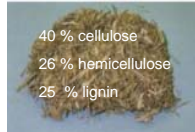
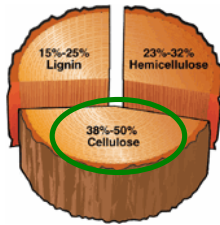
Status Hydrolysis Route



Well underway but not yet ready for commercial production

- Productivity
- Economy
 - Cost reductions
 - Enzymes
 - Equipment
 - Revenues
 - Integration

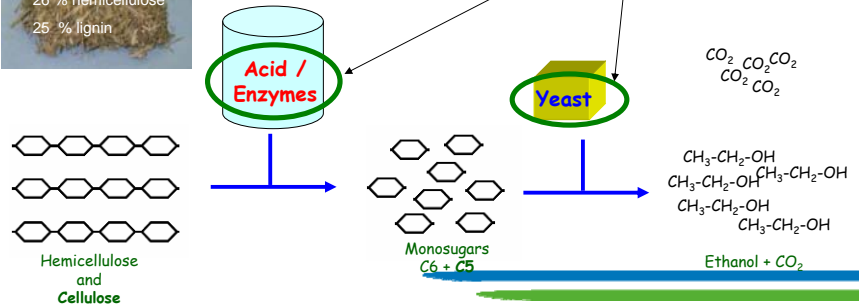




SEKAB focus

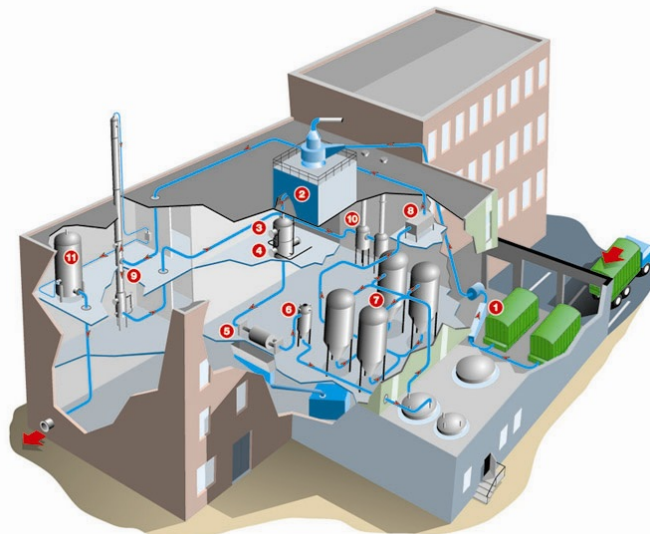
Scaling up and economy

- **productivity** in continuous operation
- raw material **flexibility**
- plant design/ investment **costs**
- scaling up of **bioprocesses**
- process **integration**



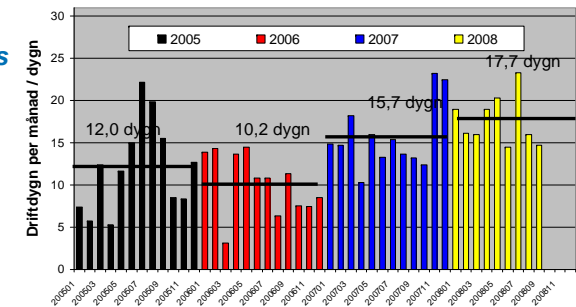
Örnsköldsvik Pilot Plant

- Complete cellulose to ethanol plant (continuous, 24 h operation)
- Two-steps dilute acid- and/or enzymatic hydrolysis
- Capacity: 2 tons of dry wood chips/ 24 h
- Investment 22 M€
- Owned together with holding companies of Umeå University and Luleå University of Technology
- Developed and operated by SEKAB E-technology

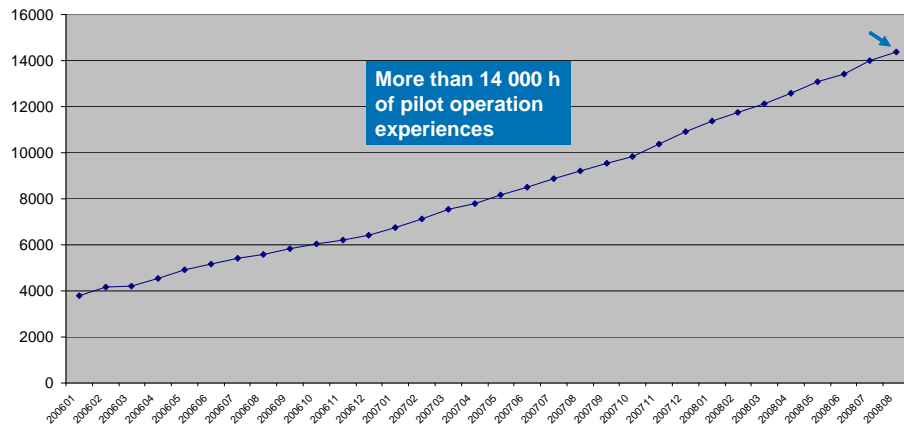


Pilot status

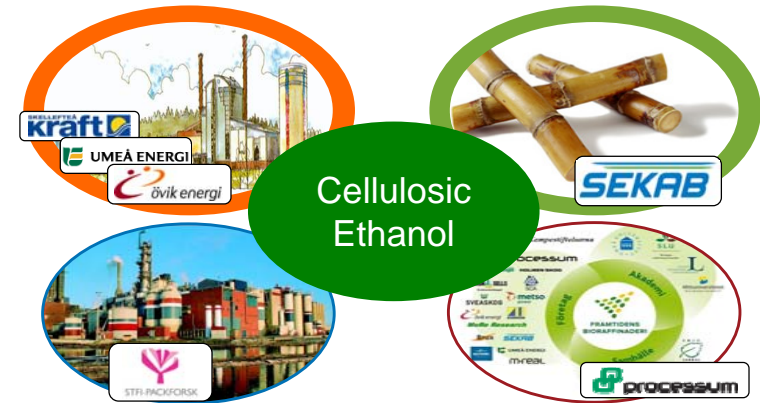
- **More than 15000 hours of operation**
- **Continuous un-interrupted operation**
– > 10 days
- **Ethanol conc after fermentation**
– 4,9 % (target>4 %)
- **Sugar conc. before fermentation**
– 80-100 g/l



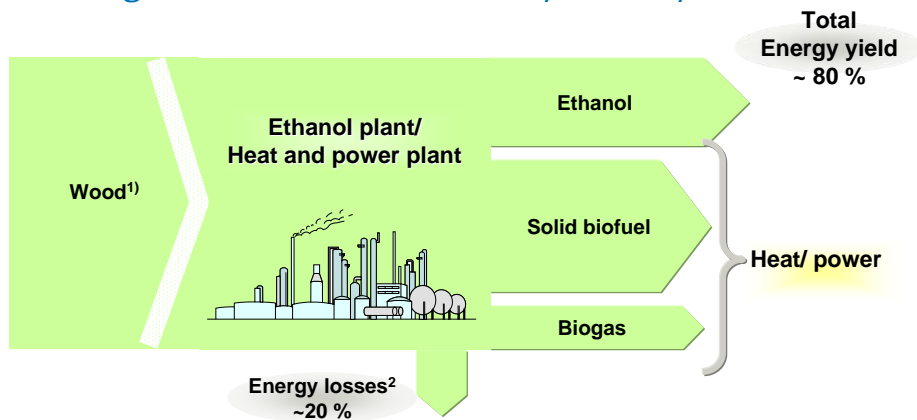
Total Accumulated Operating Hours Aug 2008



Integration is a must



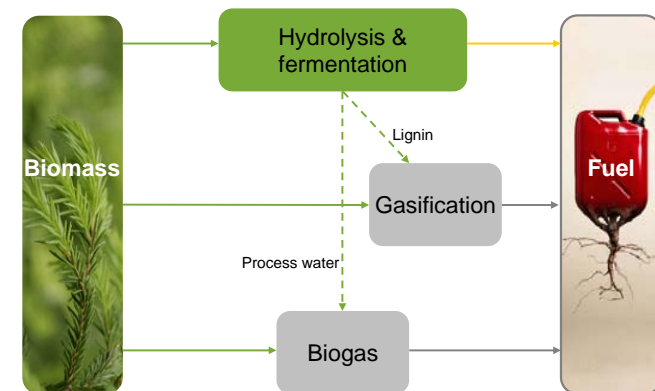
Energy balance for cellulose ethanol plant integrated with heat and power plant



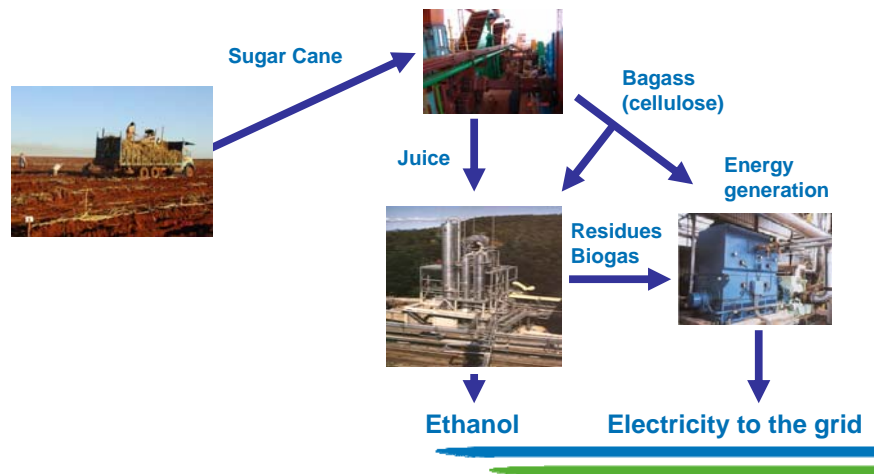
¹⁾ Based on Scandinavian softwood

²⁾ Heat and power for ethanol production included

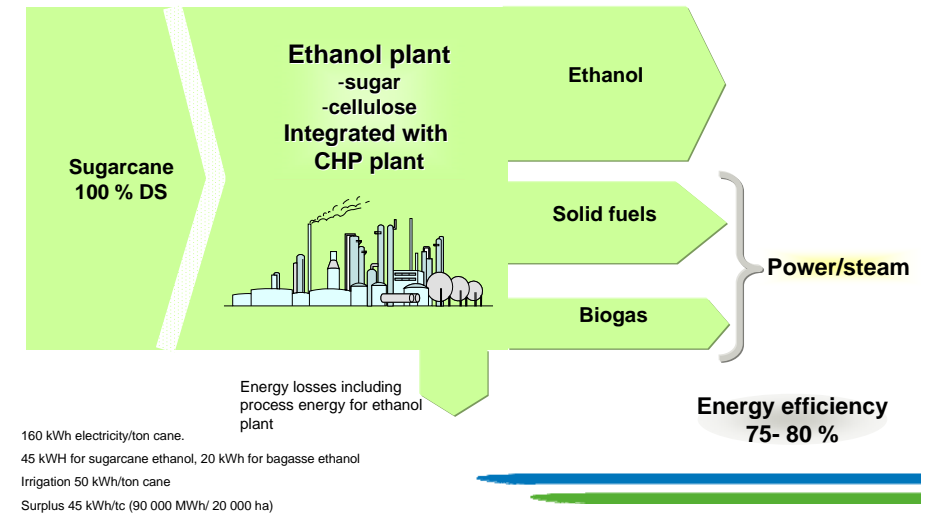
Complementary technologies



Integration with sugarcane production

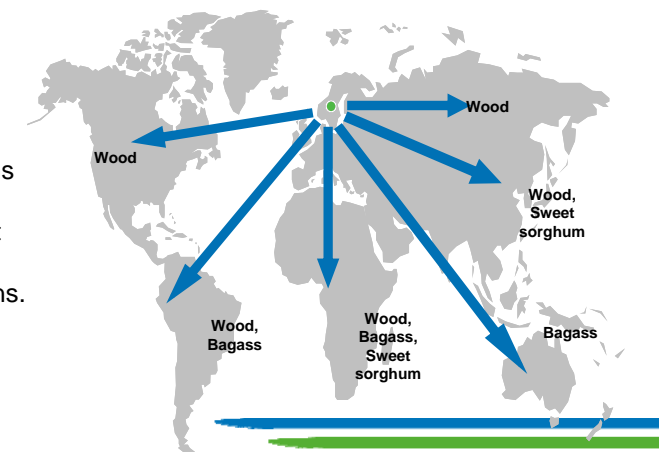


Energy balance for integrated ethanol production from sugar and bagasse cellulose

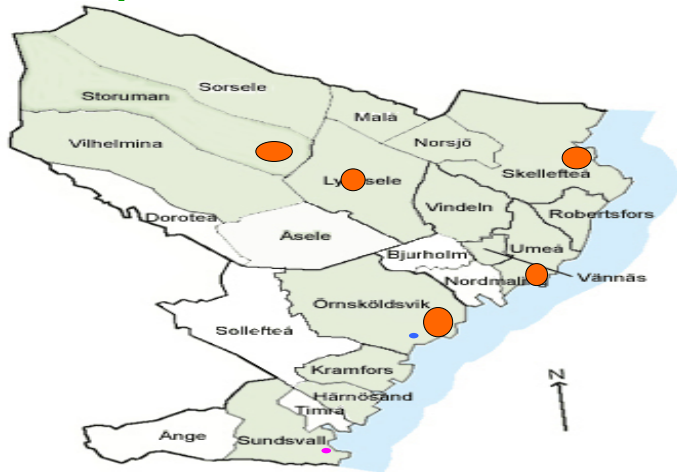


SEKAB will market and deliver the cellulose technology worldwide

Different locations and feedstock requires different technical and business solutions.



Feasibility study of ethanol/bioenergy plants for future decisions.



60 billion liter ethanol/y

BioFuel Region

2005-09-07/AS

Representative production costs

Cellulose ethanol from softwood competitive with European grain ethanol

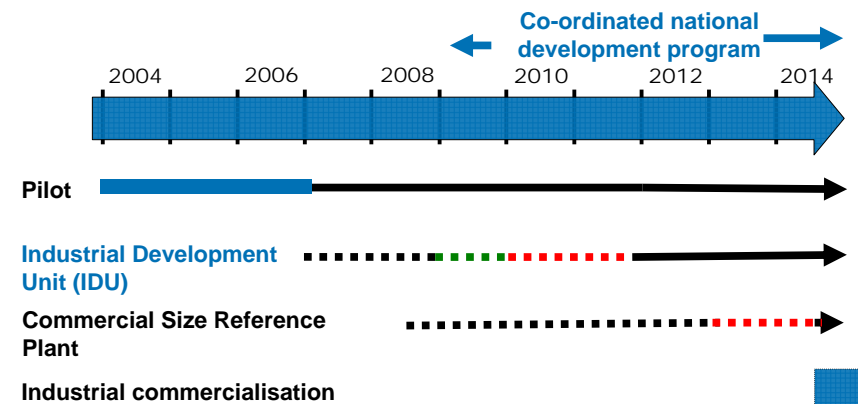
	Wheat	Softwood
Capacity (m3/y)	150 000	150 000
Cost €/l		
Feedstock	0,28	0,27
Operating costs - el, steam, chem, pers, maint. etc.	0,20	0,29
Revenue co-products	-0,08	-0,21
Production cost excl. capital cost	0,40	0,35
Capital cost	0,06	0,18
Production cost incl. capital cost	0,46	0,53

Representative production costs

Cellulose ethanol from bagass very competitive with sugarcane ethanol

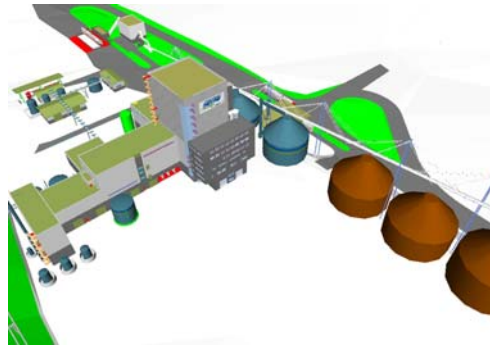
	Sugar ethanol Brasil	Bagass integrated with sugar ethanol
Capacity (m3/y)	200 000	100 000
Cost €/l		
Feedstock	0,12	0,09
Operating cost - el, steam, chem, pers, maint. etc.	0,05	0,15
Revenue co-products	-0,05	0
Prod cost excluding capital cost	0,12	0,24
Capital cost	0,17	0,07
Prod cost including capital cost	0,29	0,31

Plan for scaling up



Industrial Development Unit

- 6000 m³/year
 - Risk balance
 - Feedstock flexibility – primarily softwood and sugarcane bagass
- Enzymatic cellulose hydrolysis after dilute acid pre-treatment
- Investment 1,5 BSEK
- Connected to Ö-vik Energi's new CHP-plant in Örnsköldsvik



Lignocellulose biorefinery Top 3 in Europe



Why 6 000 m³ ?

- Necessary intermediate step for
 - reasonable technical and economical risk-taking
 - multi-feedstock development
- Conclusion shared with collaboration partners and other industrial actors in the field

Other actors intermediate steps

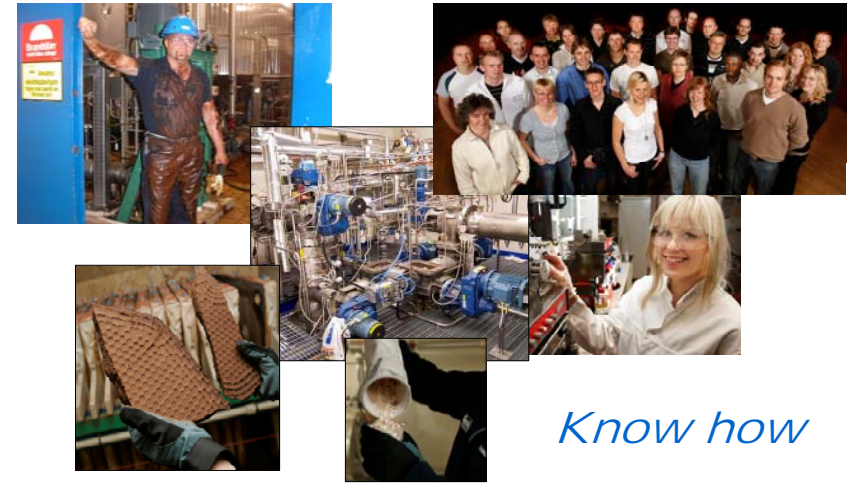
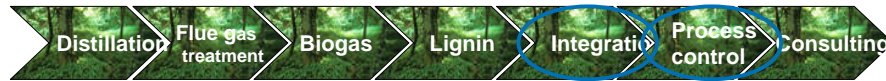
<u>Company</u>	<u>Capacity</u>	<u>Feedstock</u>	<u>Start</u>
Iogen, Canada	4 000 m ³	Straw	2000
Verenium, USA	5 000 m ³	Forest residues, bagasse	2008
Abengoa, Spain	5 000 m ³	Straw	2008?
Mascoma, USA	1 900 m ³	Forest residues, recycled fiber, straw	2009
DONG Inbicon Denmark	6 500 m ³	Straw	2009? Not complete

SEKAB

- providing knowledge



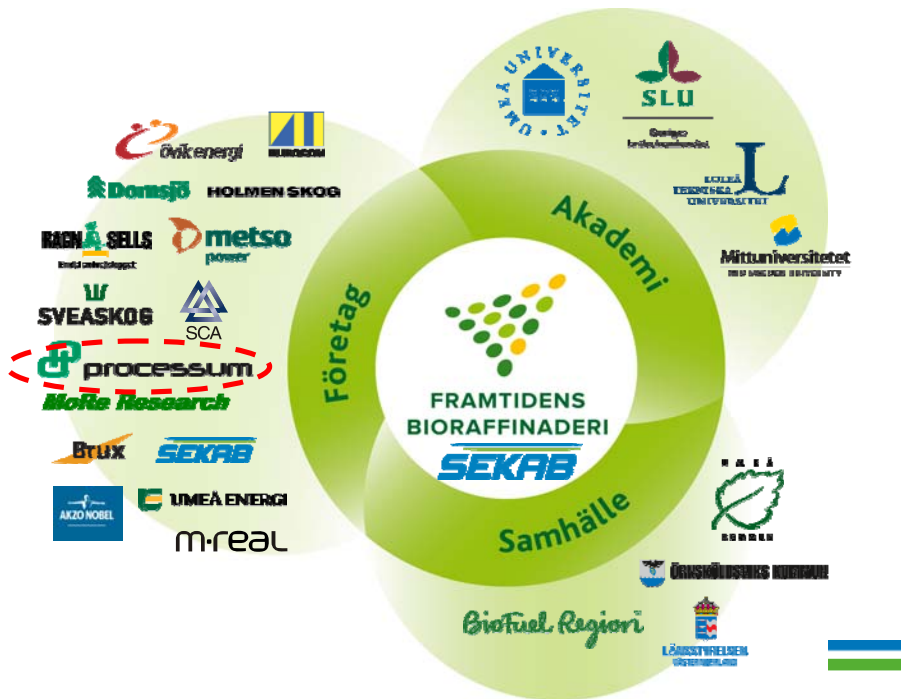
- Focus on key technologies
- Patents
 - Own patents + licenses
- Know How
 - SEKAB + network



Know how

Consortium

- Partners:
 - Metso Paper, reactor system for pretreatment.
 - Novozymes, enzyme supplier.
 - Taurus pentose yeast, Lund
 - Chematur, fermentation, distillation
 - Purac, waste water treatment/biogas
 - Eurocon, project computer system, control/el
 - Epsilon, layout, mechanical construction
 - WSP, civil consultant
 - SWEPRO, environment analyze and permission



Competitors



Source: Novozymes

Political decisions and public opinion...



Market potential for Europe (EU 25) to 2020

10% of gasoline and diesel replaced with biofuels - approx. 400 TWh or 80 million m³ ethanol is needed.

Each plant 140 000 m ³ ethanol/ year	0,8 TWh
Number of plants needed	500

There will be several technology providers – SEKAB will be one of them!



THANK YOU !

www.baff.info
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www.biofuelregion.se

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