



Development of cellulose ethanol and Swedish progress

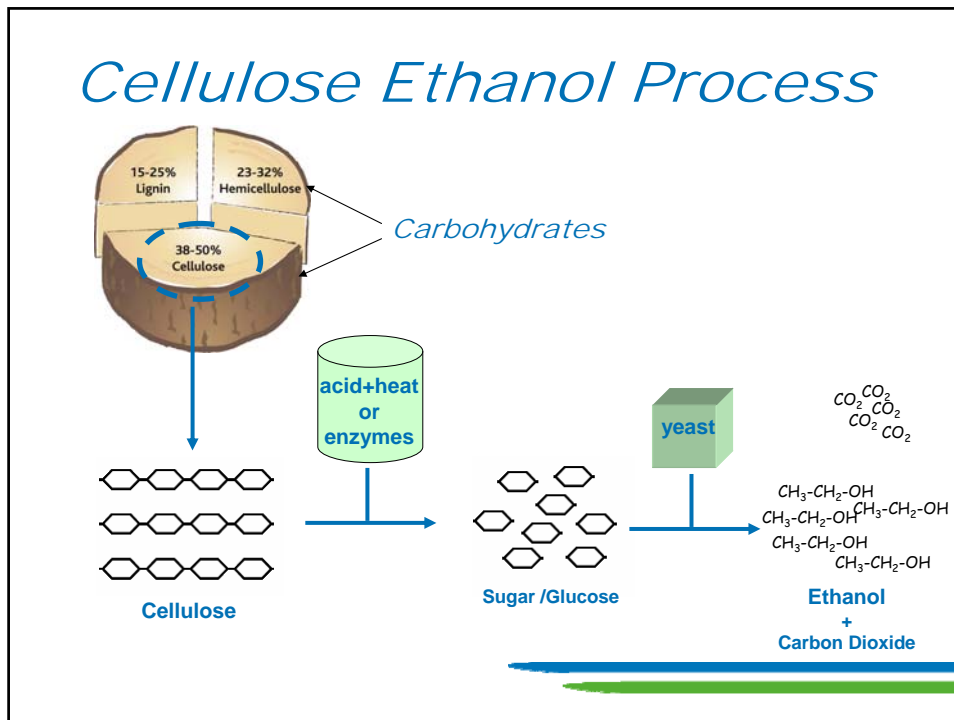
**Sune Wännström, Director of Research and Development
SEKAB E-Technology**

Outline

- *Cellulose ethanol*
- *Technology status*
- *SEKAB priorities and approach*
- *Commercialisation*



Cellulose Ethanol Process



One Ethanol - but different routes

- **1st generation ethanol - today**
 - Sugar (e.g sugar cane); fermentation
 - Starch (e.g wheat, corn); hydrolysis + fermentation
- **2nd generation ethanol**
 - Cellulose; hydrolysis + fermentation
 - Alternatives; Gasification ($\text{CO}+\text{H}_2$) - catalysis



Why cellulose?

Cellulose feedstocks



- *Swedish ethanol research programmes on wood cellulose since mid 80's*
- *SEKAB increasing focus on bagasse*

Status

Cellulose technology well underway but not yet commercial

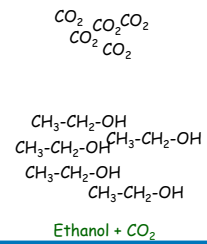
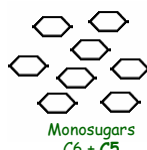
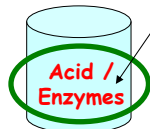
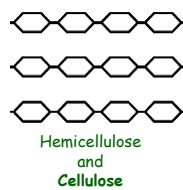
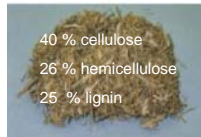
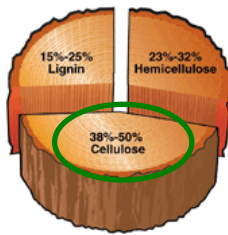
- **Scaling up**
 - Reactors/ equipment
 - Continuous operation
- **Economy**
 - **Cost reductions**
 - Enzymes/ chemicals
 - Equipment
 - **Revenues**
 - Integration

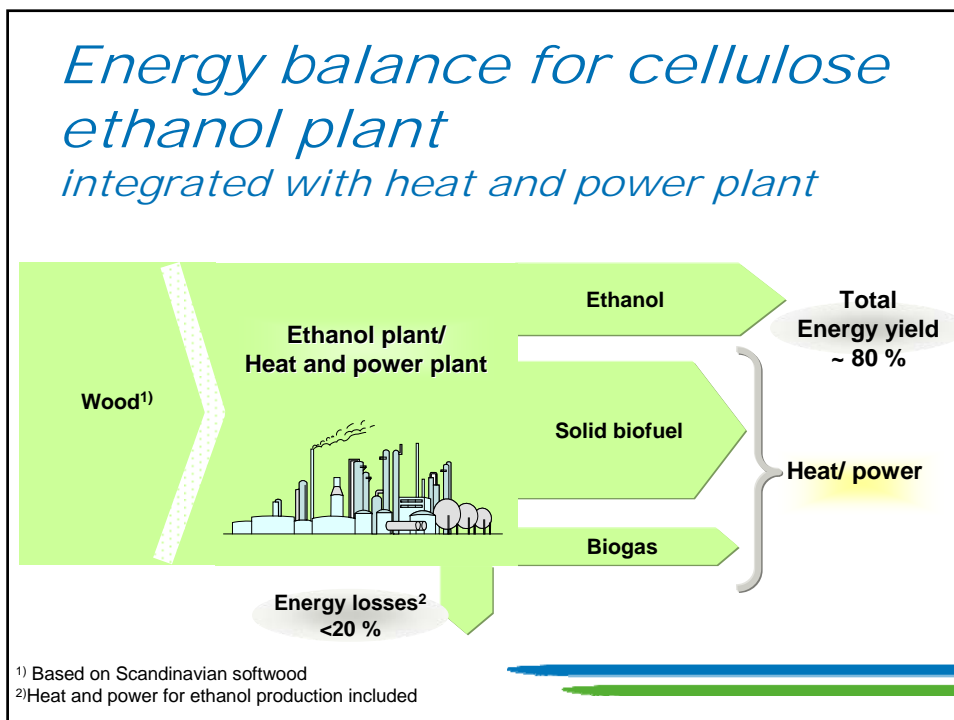
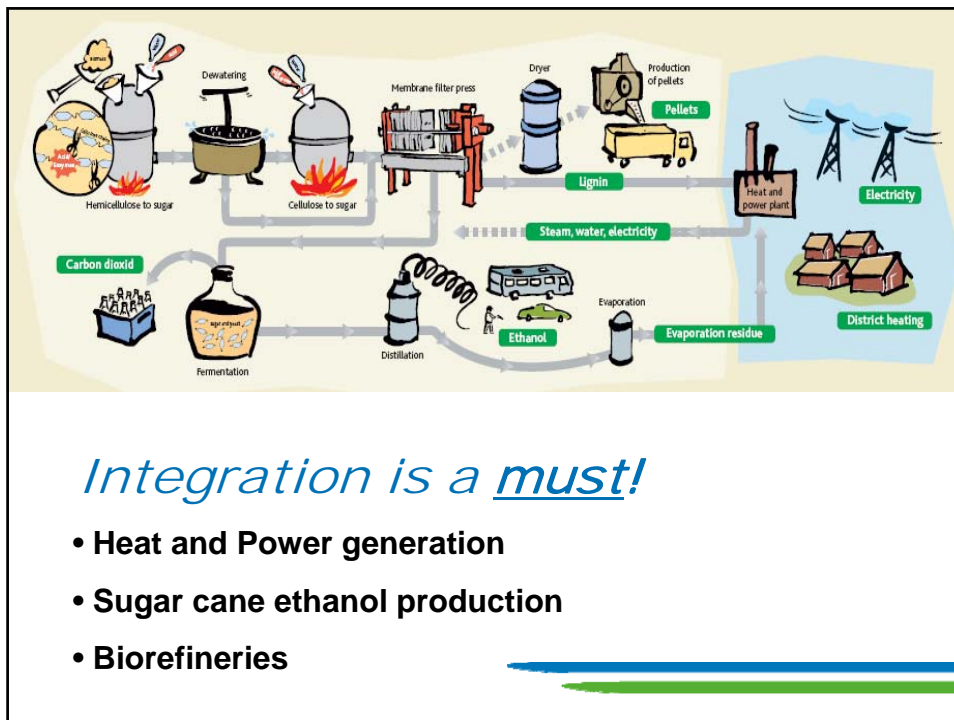


SEKAB focus

Scaling up and economy

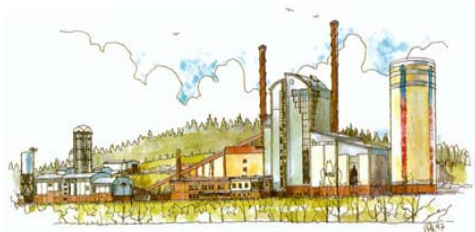
- **productivity** in continuous operation
- raw material **flexibility**
- plant design/ investment **costs**
- process **integration**
- improved **bioprocesses**



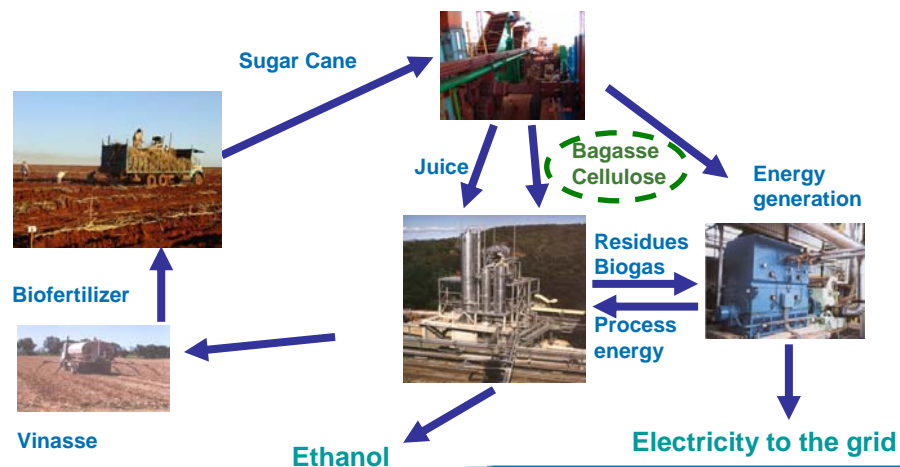


Options

- **Solid residue**
 - Direct incineration for heat and power production
 - Production of pellets
- **Biogas**
 - Direct incineration for heat and power production
 - Refining of biogas



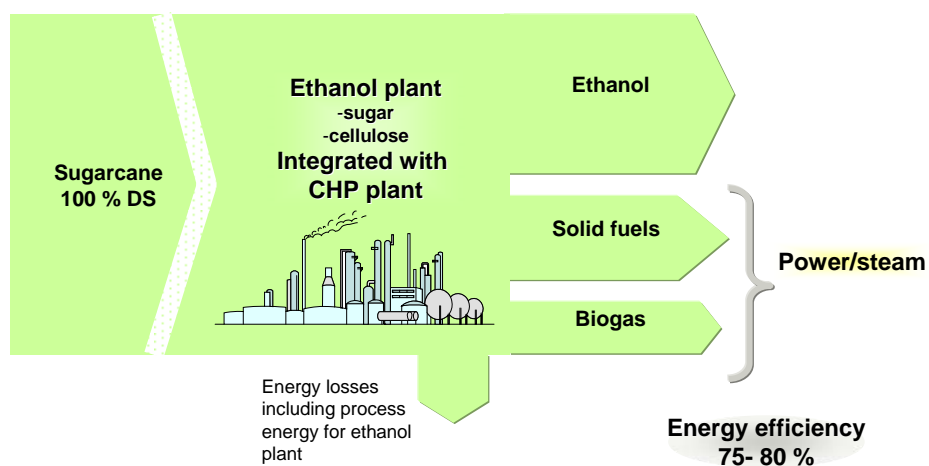
Integration with 1st generation ethanol production



Feedstock *Litre ethanol per ha/year*
+ cellulose

Corn + stover	3.000 +1.500	4.500
Wheat + straw	2.000 +1.000	3.000
Sugarcane + bagasse	8.000 +4.000	12.000

Energy balance for integrated ethanol production from sugar and bagasse cellulose





Cellulose Ethanol R&D Pilot Plant in Örnsköldsvik

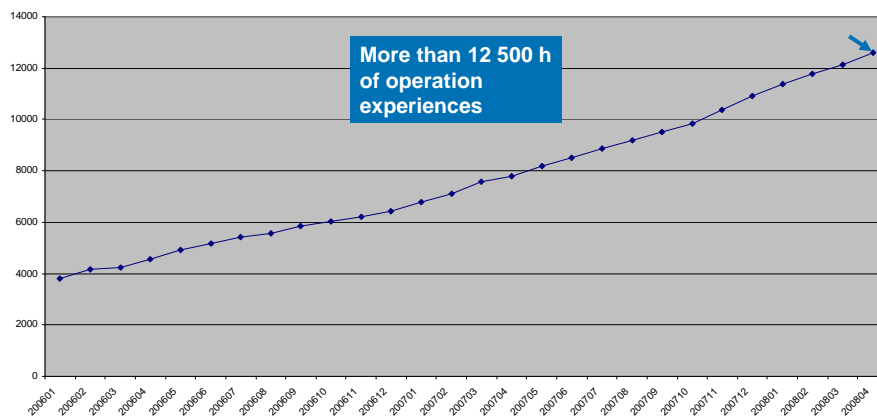
Örnsköldsvik Pilot Plant

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



Total Accumulated Operating Hours April 2008

Akkumulerad drifttid i timmar

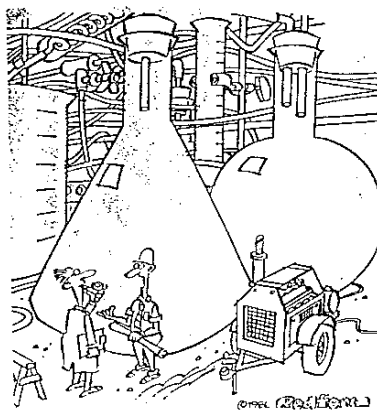


Strong know-how



Stepwise scaling up

- Complex, integrated processes
- Intermediate step needed for commercial scale process guarantees



"Got a few problems going from lab scale up to full-scale commercial."

Plans for scaling up

Pilot plant, 2004

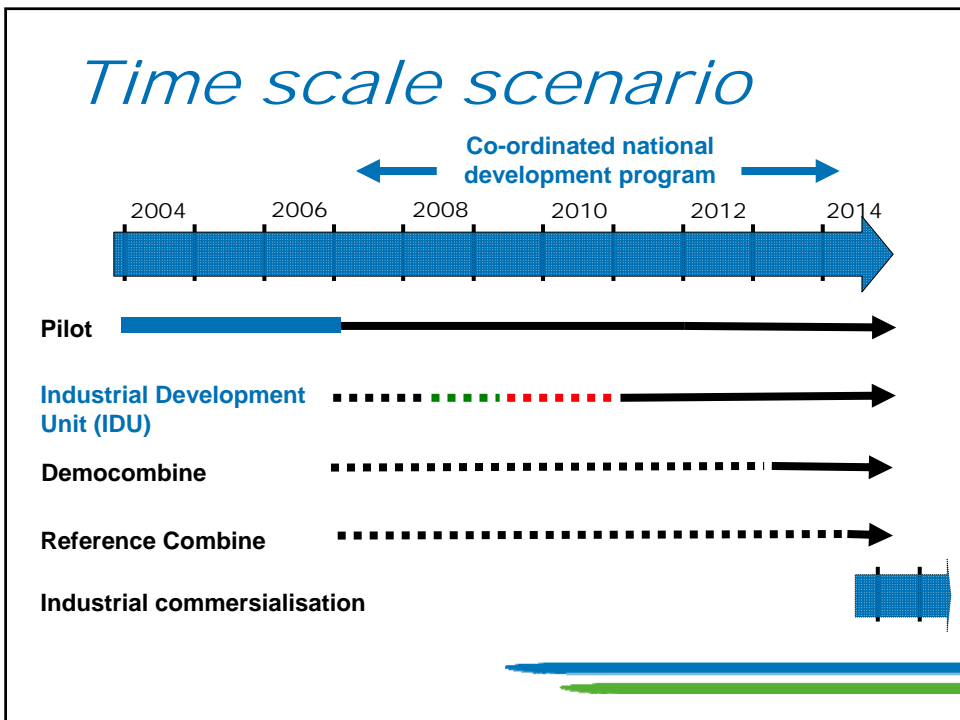
Dilute acid + enzymatic hydrolysis
Örnsköldsvik, ~150 m³ /year

Ind. Development Unit

Enzymatic hydrolysis (dilute acid)
Connected to heat and power plant
Örnsköldsvik, ~6000 m³ /year

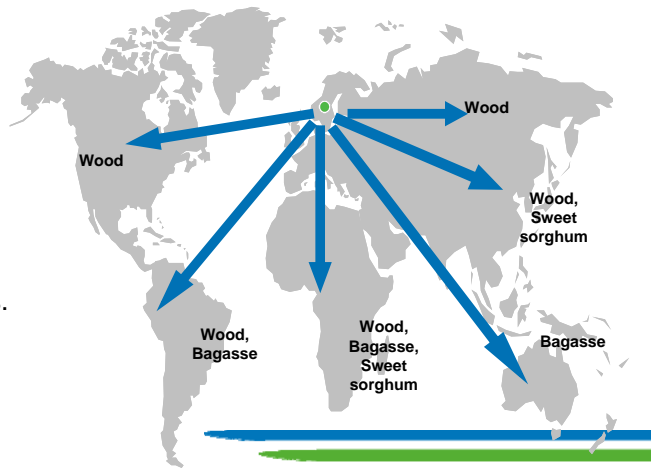
Integrated demo plant

Integrated with heat and power plant
Location not set, >60 000m³ /year

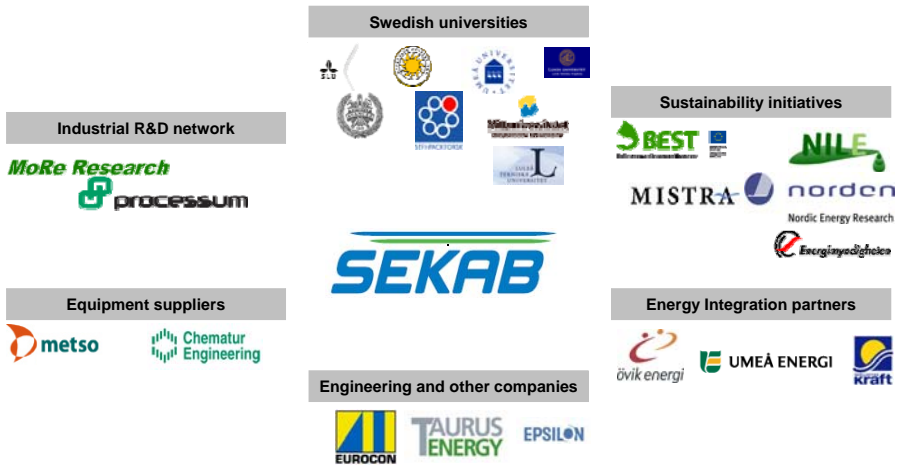


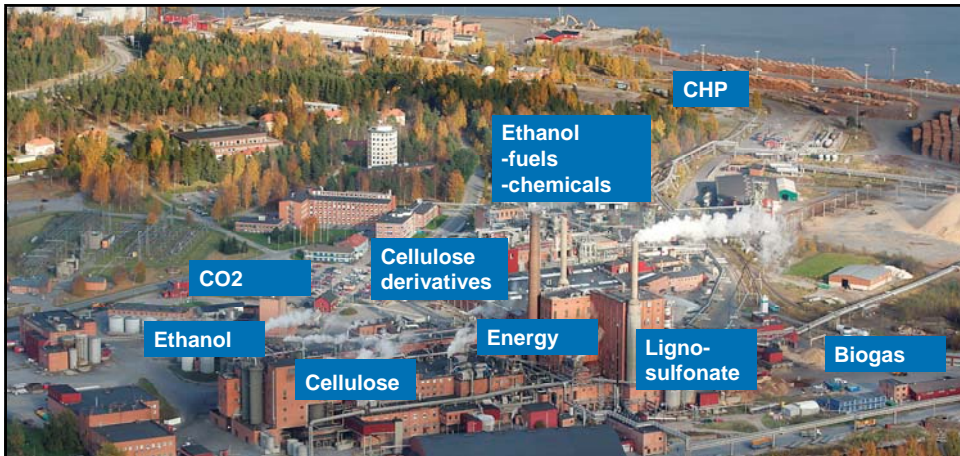
SEKAB will market and deliver the cellulose technology worldwide

Different locations and feedstock requires different technical and business solutions.



A Strong Technology Platform and a unique research and industrial network





*The most extensive
lignocellulose biorefinery
in Sweden*



*SEKAB Cellulose
Ethanol Strategy*

- Development and scaling up of cost efficient process technology for integrated cellulose ethanol production
- Combining long industrial experiences from cellulose processing with pilot and IDU in continuous operation
- Raw materials flexibility
- Strong networks and alliances for R&D and commercialisation





*Thank
You!*

