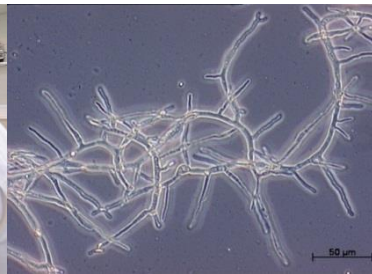


# The Processum cluster - Fish feed and Chemicals from the forest

Clas Engström

*Keflavik november 2014*

processum your Science Partner



**RI  
SE**  
INSTITUTES



## SP PROCESSUM

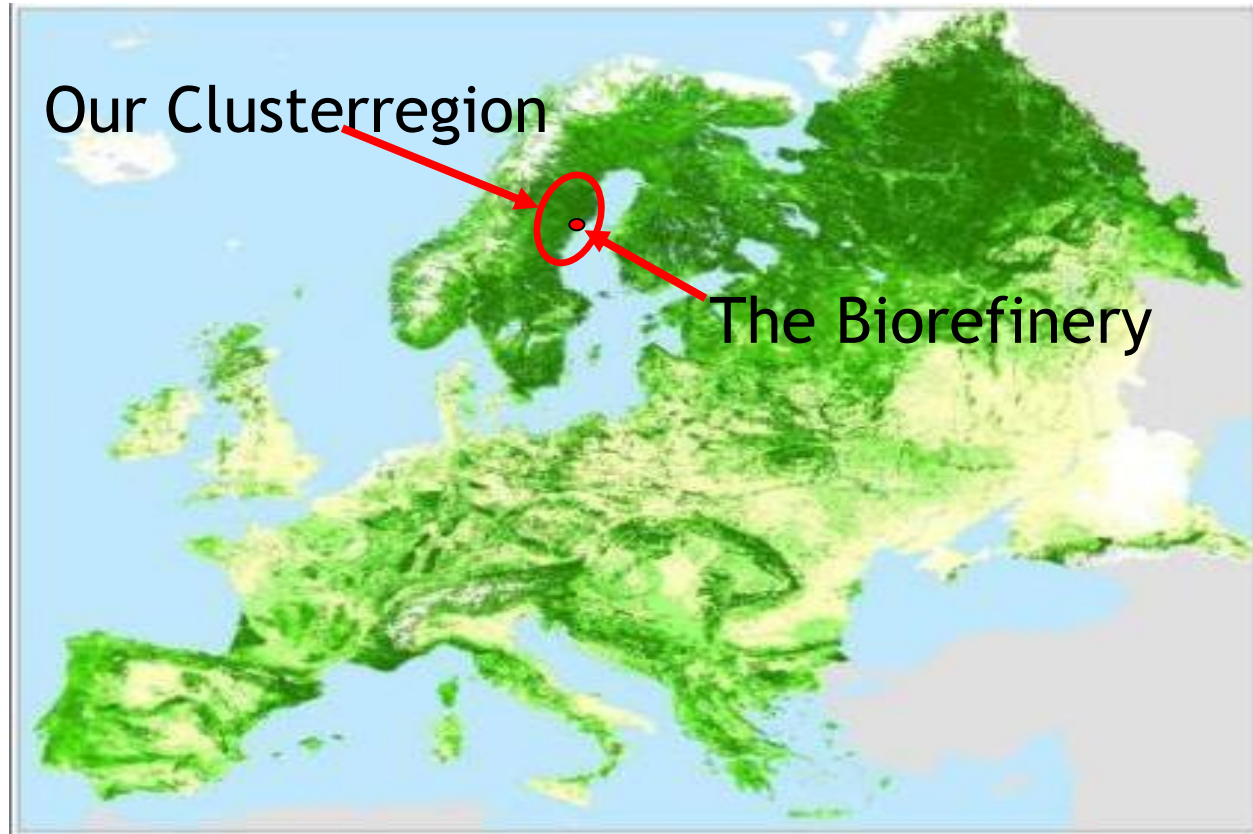
Industrial Research Institute,  
Cooperation, Open Innovation,  
Business-oriented, Clusterhost, R & D

- Started 2003
- Turnaround 20 million SEK
- 17 employees
- 130 Biorefinery R&D project since 2008
- Hosting the VINNVÄXT-initiative the Biorefinery of the Future
- Part of the SP-group since may





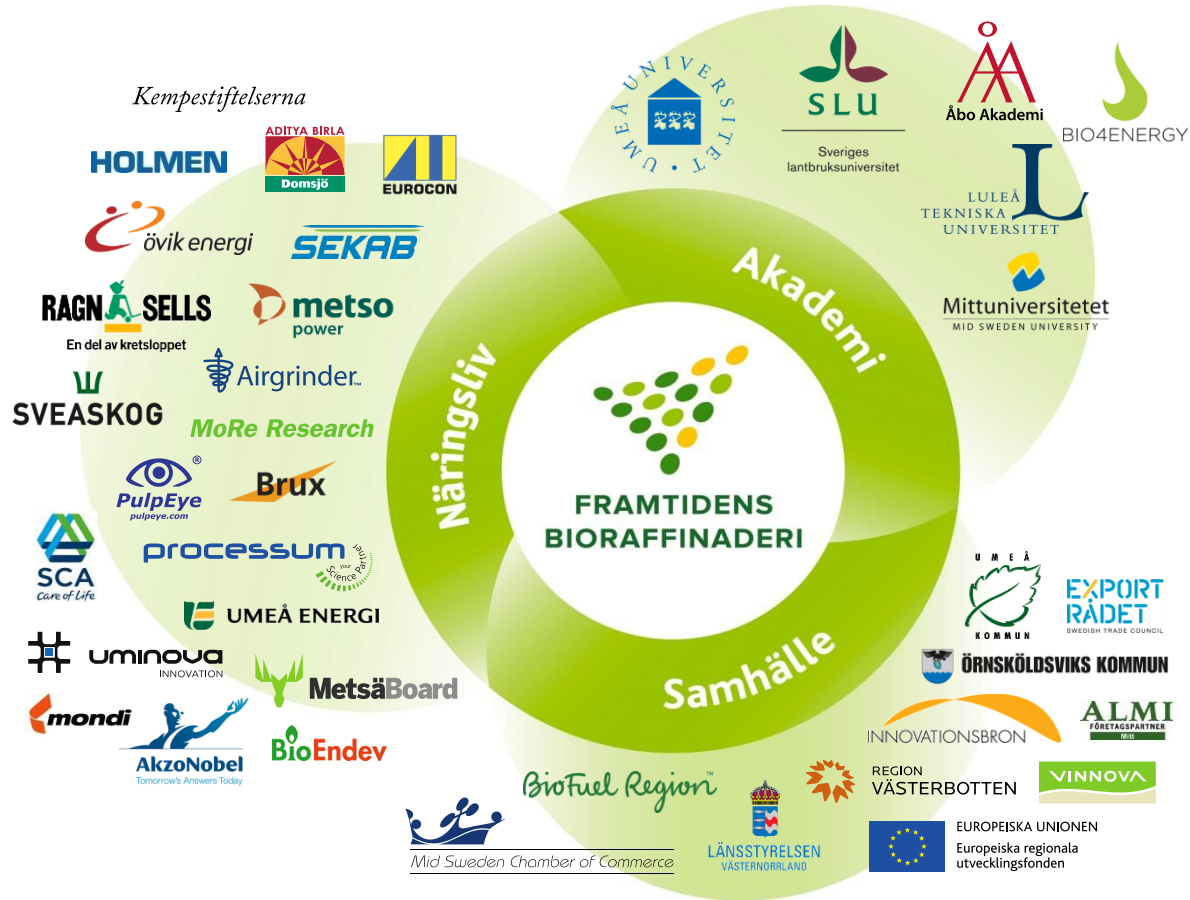
# Our Region



© 2011 Processum

# Biorefining in a cluster set up

THE BIOREFINERY  
OF THE FUTURE







1 million m<sup>3</sup>

Sustainable Forestry!

Yearly annual forest growth  
120 million m<sup>3</sup> = 200TWh



# The Biorefinery

THE BIOREFINERY  
OF THE FUTURE



First Industrial  
Torrefaction of its Kind

Storövik energi  
city &  
district heating



Brux  
Engine



processum

MoRe Research

Linde Gas  
Ethanol  
AGACO<sub>2</sub>

Cellulose  
derivatives

HOLMEN  
SKOG

•fuels  
•chemicals



tives

Domsjö  
cellulose

Energy

SEKAB

Ligno-  
sulfonate

Biogas





# Opportunities



# Processum R&D council

Funding from VINNOVA and EU for promoting growth of the Swedish biorefinery industry

## Projects

Succinic acid and Butanol  
Electricity from low-value heat sources  
Yeast project  
Hemiextraction  
NIR project  
Hemp project  
Green liquor sludge  
Fibersludge project  
Lignosulfonate project  
Fertilizers  
Biogas  
Green chemicals  
Refined lignosulfonate  
Methanol  
Lignin  
Ash  
Cellulose reining  
R/F-project  
Multilayer project  
Trainee program

## Description

Production of succinic acid and butanol by fermentation  
Production of electricity from low-value heat sources  
Optimization of industrial yeast cultivation within the BoF-cluster  
Extraction of polymeric hemicellulose  
Analysis of lignin using "near infrared spectrometry"  
New bio-based fuels  
Optimization of the BoF-cluster  
Investigate the potential of producing new chemicals within the BoF-cluster  
Methods for lignosulfonate refining  
Methods for purification of methanol from kraft pulp mills  
Quality improvements and new applications for lignin from hydrolysis processes  
Optimization of the cultivation of energy crops  
New materials for replacement of tropical wood in plywood  
Modification of ashes to enable return of ashes to the forests  
Refining of the cellulose within the BoF-cluster  
Optimization of retention and formation during paper production  
Increase the strength of TMP-pulp.  
A trainee program with five of the companies within the BoF-cluster

Ideas

About 0.5 M EUR/year  
for applied R&D projects

New products  
and processes



# Wood biorefinery products



Candles



Plywood substitute



Aviation fuel



Bioethanol



Fish feed



Fish



Viscose thread



Green chemicals



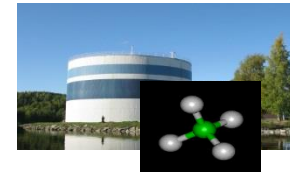
Concrete additive



Nanocellulose



Torrefaction



Biogas

# Processum pilot equipment

- Bioreactor
- Chemical reactors (ATEX)
  - Flow reactor
  - Gas/liquid reactor
  - Batch reactor
- Pilot for biomass drying
- Torrefaction pilot
- Algae cultivation pilot
- Unit operations
- Viscose spinning pilot
- Pretreatment reactor



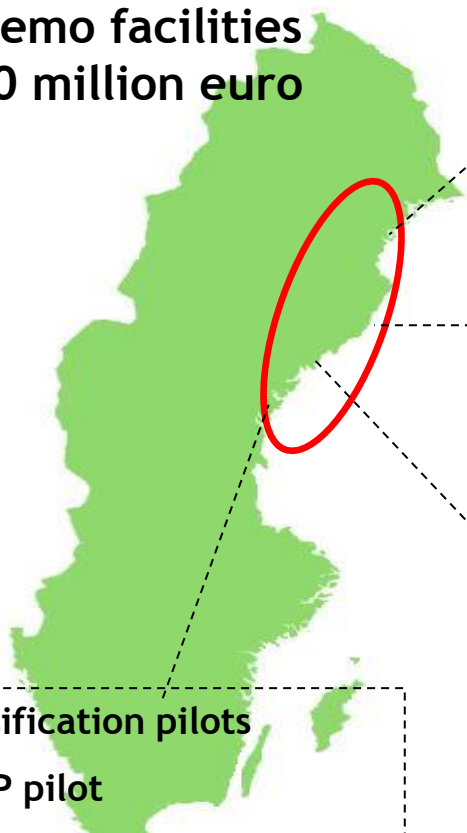


# A unique test site for lignocellulose processing

THE BIOREFINERY  
OF THE FUTURE



Pilot and demo facilities  
worth >100 million euro



DME pilot

Entrained flow gasification pilot

Indirect gasification pilots

Torrefaction pilot

Algae pilot

Dryer pilots

Wood fractionation pilot

Pelletizer pilot

Biorefinery Demo Plant

Chemical synthesis pilot

Viscose and spinning pilot

Pulping pilot

Membrane filtration pilot

Unit operation pilots

Gasification pilots

TMP pilot

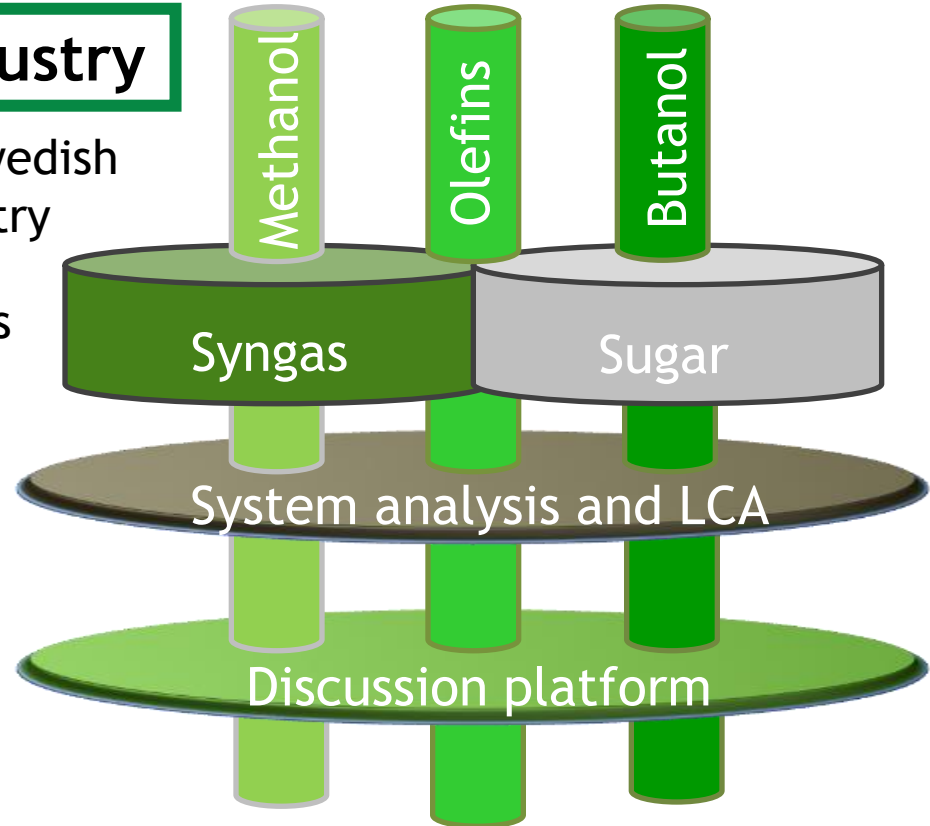
Chipping pilot



# Forest Chemistry - back to the future

## Forest industry + Chemical industry

- ➔ A unique collaboration between the Swedish chemical industry and the forest industry
- ➔ Platform chemicals from wood for making green polymeres and chemicals
- ➔ Renewal of two important export industries in Sweden
- ➔ Adresses climate change
- ➔ Will identify the need for political decisions to realize the bioeconomy vision





### 3 » DEMAND FOR BIO-BASED PRODUCTS IS GROWING

CURRENT ANNUAL GROWTH OF  
THE MARKET FOR BIO-PLASTICS<sup>3</sup>:



**20%**

WORLDWIDE PRODUCTION  
CAPACITY OF BIO-POLYMERS<sup>4</sup>:



MILLION  
TONNES

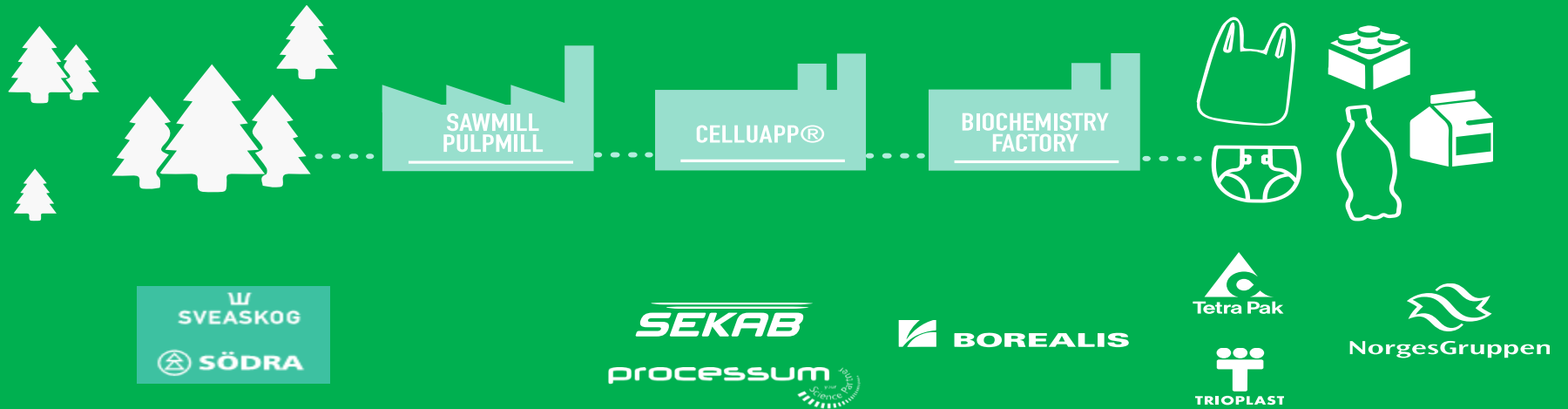
**3.5**

2011

**12**

2020  
(expected)

# LOCALLY GROWN PLASTICS







# Design and Status of the Industrial-Scale Torrefaction Plant in Holmsund, Sweden

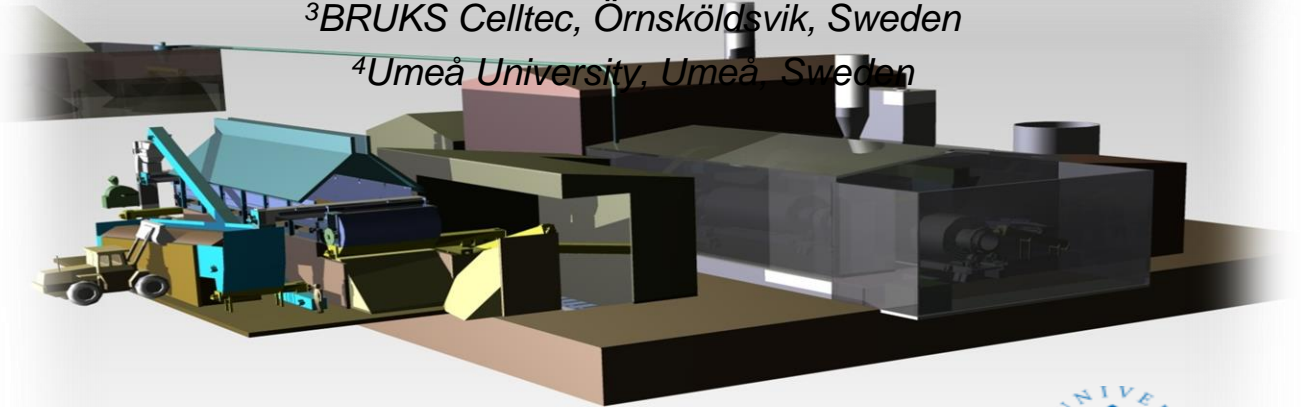
*P Fridström<sup>1</sup>, M Berglund<sup>1</sup>, U Bojner<sup>2</sup>, T Lindgren<sup>3</sup>,  
M Nordwaeger<sup>1,4</sup>, I Olofsson<sup>1,4</sup>, K Håkansson<sup>1,4</sup>, A Nordin<sup>1,4</sup>*

*<sup>1</sup>BioEndev, Örnsköldsvik, Sweden*

*<sup>2</sup>Torkapparater, Stockholm, Sweden*

*<sup>3</sup>BRUKS Celltec, Örnsköldsvik, Sweden*

*<sup>4</sup>Umeå University, Umeå, Sweden*





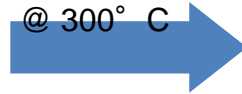
**BioEndev**

- Bulky raw material
- Wet, hydrophilic
- High milling costs
- Non-feadable
- Low energy content
- Inhomogeneous
- Ash related
- Risk for biocontamination



Biomass

Torrefaction  
@ 300° C



(low value heat  
via process  
integration)



Torrefied biomass

▶▶▶ **solved!**

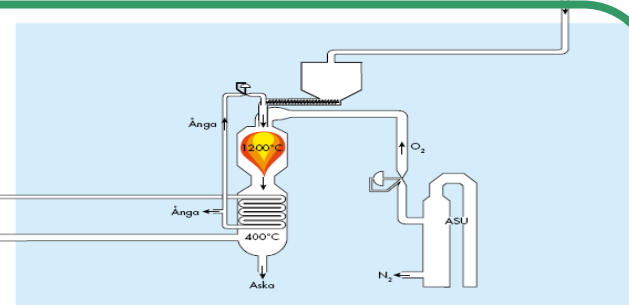
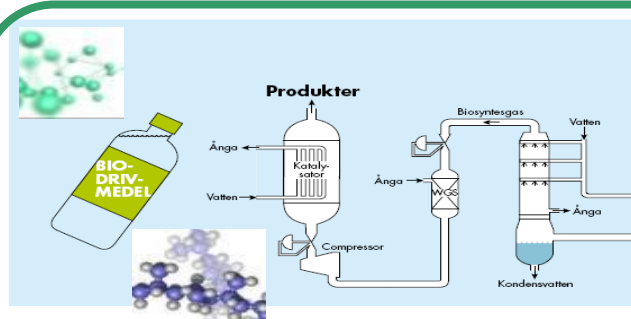
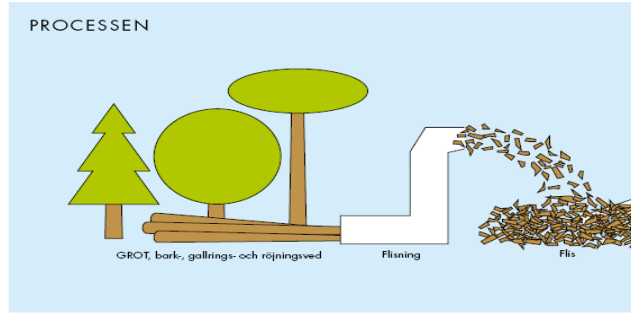
- + High density, compactable
- + Dry and hydrophobic
- + Friable = **lower grinding costs (10%)**
- + **Feadable** (spherical particles)
- + Higher heating value (as coal)
- + Homogeneous
- + Reduced problems
- + No biocontamination

**Further  
Refinement**





# BioEndev



# BioEndev

**Comercially available:** Siemens, GE, Conoco Philips, Shell, Chemrec, Haldor Topsoe, Sasol, Rentec, Oxford Catalysts.....





**BioEndev**

Transport requirement of 1 kWh for:



**Pelletized  
torrefied  
wood**

**Wood  
pellets**

**Wood  
chips,**

# From wood to food



Wood

→  
Industrial residual  
streams



Single cell protein



Food

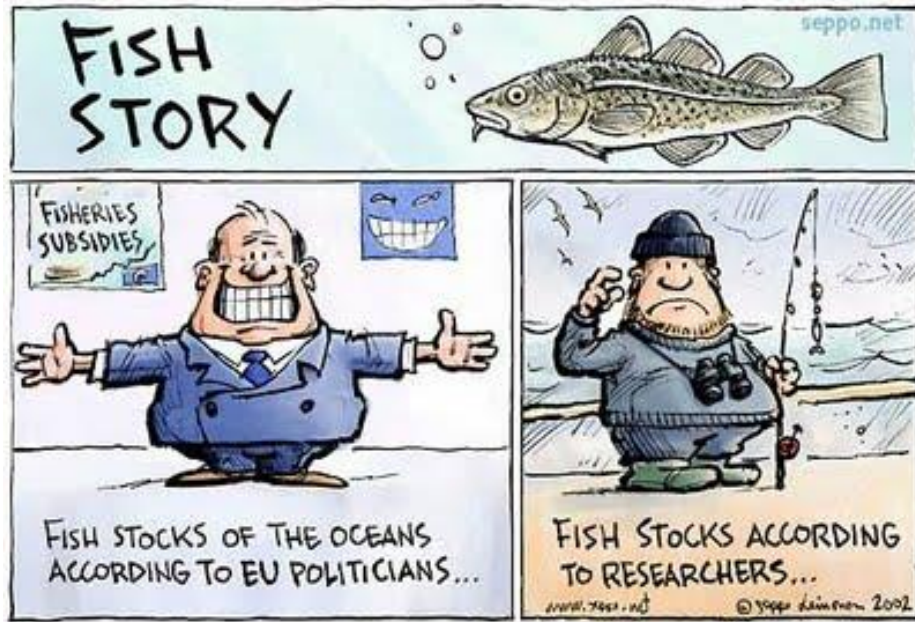


Cultivated fish





# Background

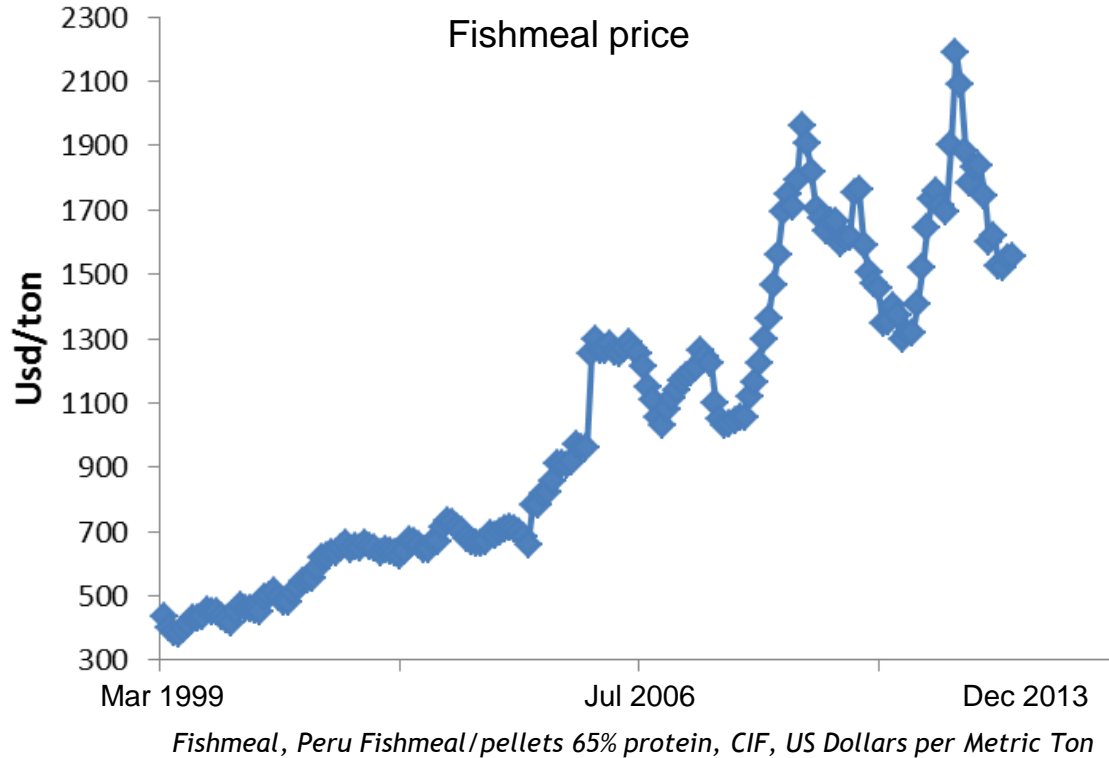


- The human population is projected to 9 billion in 2050
- The demand for fish is estimated to increase with 300% within 40 years
- 80% of the oceans are today fully exploited, overexploited or depleted
- A considerable share of the fish must come from aquaculture in the future

➡ Fish production through aquaculture is projected to double within the next decades and so is the the demand for protein for feed



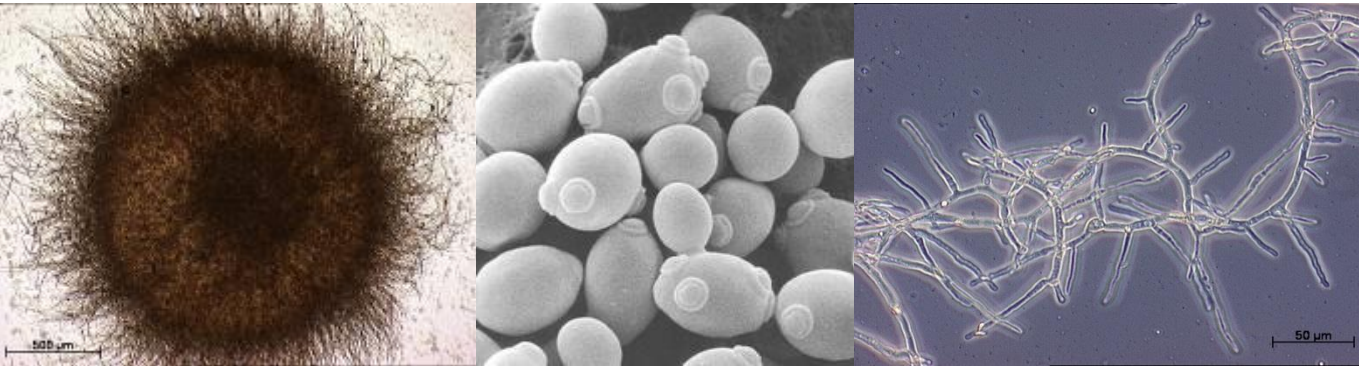
# Background



- The annual fishmeal production is about 5-6 million tons
  - Fishmeal available for aquaculture is now falling short of demand
- ➔ This shortage must be met by alternative protein sources!

# Benefits of "Single cell protein"

- Single cell protein consist of fast growing microorganisms (fungi, bacteria, algae)
  - Rapid protein production (from kg to tons in 24h)
  - Can be produced from residual process streams from the biorefinery industry
  - Environmental benefits! No fish depletion, no deforestation of rain forests, less transports.
- ➔ A potential new co-product for the biorefinery industry



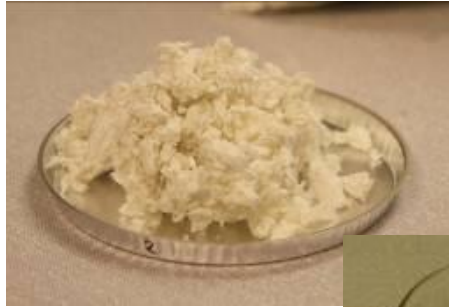
# Residual streams and microorganisms

Spent sulfite liquor (SSL)  
SSL-permeate  
SSL-ethanol stillage  
Fiber sludge  
Hemicellulose hydrolysate



The Biorefinery of Örnsköldsvik, Sweden

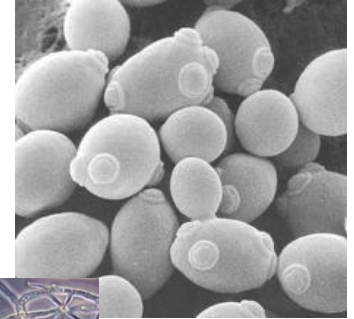
*Paecilomyces variotii*  
*Fusarium venenatum*  
*Rhizopus oryzae*  
*Candida utilis*



Fiber sludge



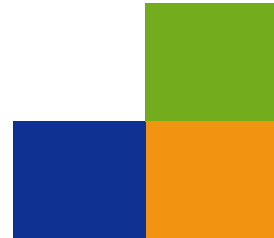
SSL-permeate



Yeast



Filamentous fungi





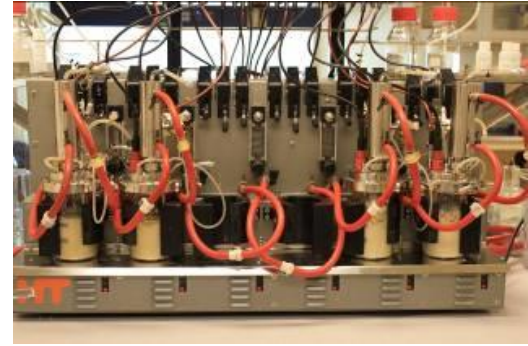
# From lab to demo scale



**Agar plates**



**Shake flasks**



**Laboratory bioreactor**



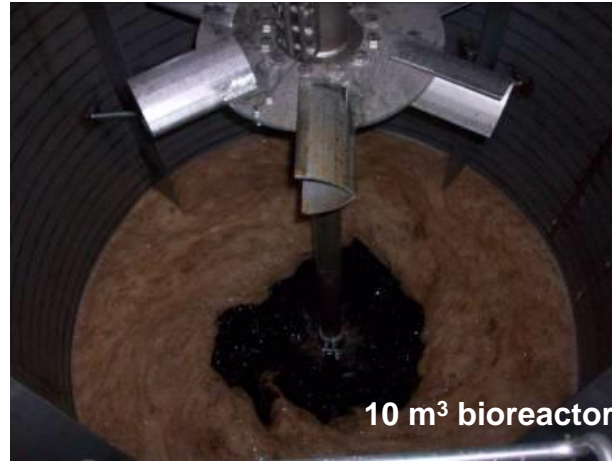
**Pilot bioreactor**



**The Swedish Biorefinery Demo Plant**



# Demo experiment



# Feed and feeding experiments

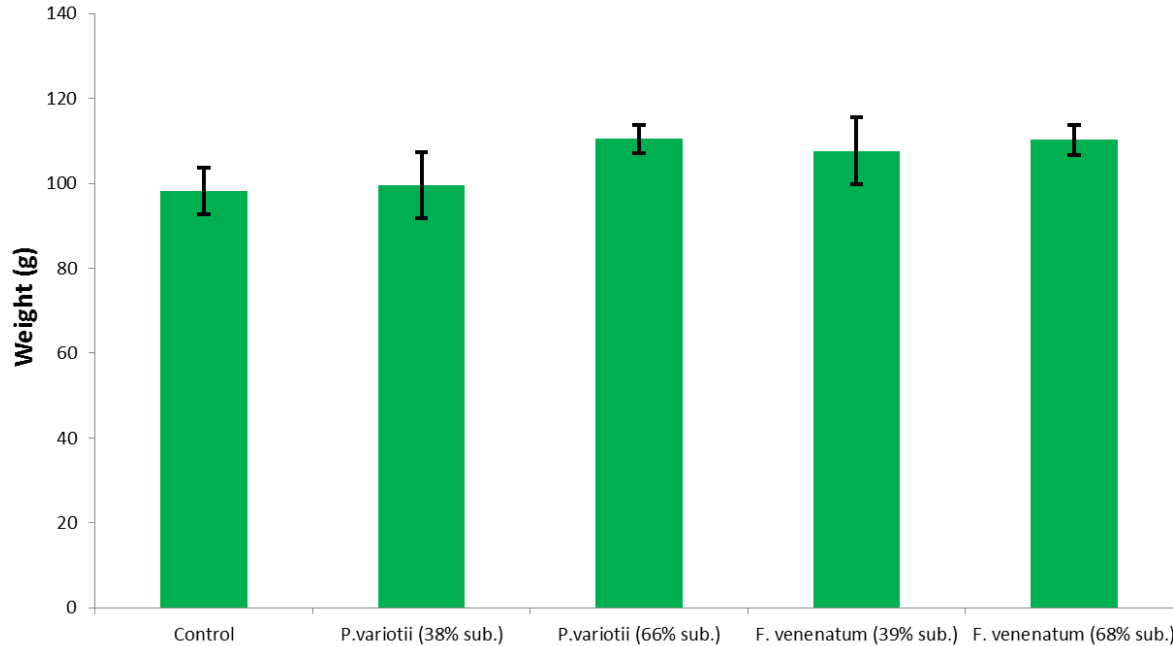
- ➔ Various feed formulations with up to 68% fishmeal substitution was produced
- ➔ The feeding experiment was performed on the fish Tilapia
- ➔ 4x25 fishes for every feed formulation





# Feeding experiments

## Fish growth



➔ The fish growth was similar or better than the control

➔ 12% better growth was achieved with 66% fishmeal substitution using *P. variotii*



Network and credibility takes a long time to build

Tacit knowledge very important

Long term finance important to build the cluster

Cooperative spirit successful

Network increasingly outside the region

Successful in strengthening existing industry structure

We are strong in R&D, but big scale ups and commercialisations are a challenge

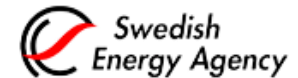
**Demos and pilot parks** are important

Policy very important to take the next step – long term **demand boosting** measures – **systematic change take time** – creating the new bioeconomy is not a quick fix

# Thank you for your attention!



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*En investering för framtiden*

