Pulp Mills

The Optimum Location for Biorefineries

Gasification Technologies Conference 2009
Colorado Springs, October 4-7, 2009

Ingvar Landälv
CTO
Chemrec AB, www.chemrec.se
Our shareholders

Our shareholders provide more than capital

- **Vantage Point Venture Partners:**
  - US venture capital company with $5bn under management, strong management skills and early commitment to Cleantech

- **Volvo Technology Transfer:**
  - The venture capital arm of AB Volvo, the world's largest heavy diesel engine manufacturer

- **Environmental Technologies Fund, ETF:**
  - Largest European venture capital fund dedicated to Cleantech investments

- **Nykomb Synergetics**
  - Privately held Swedish company with strong tradition in gasification technology and project development

Our board members:
- Bernie Bulkin
- Humberto Vanieri
- Anders Brännström
- Henrik Olsén
- Athol Tricket
- Max Jönsson
Concept Background

What is Black Liquor?
A typical Pulp Mill of Today - On Feedstock and One Product -

Pulp Wood

Recovery Boiler

Utility Boiler

Black liquor bioenergy
The Pulp Mill turned to a Biorefinery - two Feedstocks and two Products -

- Pulp Wood
- Renewable energy

- Syngas to fuels
- Black Liq. to fuels

CHEMREC Energy to Succeed
Black Liquor at room temperature

WHY BLACK LIQUOR?
Black liquor uniquely suitable for gasification

- **Liquid**
  - Easy to feed to a pressurized gasifier
  - Can be atomized to fine droplets
  - Rapid gasification rates
  - Stable properties over time

- **Efficient gasification**
  - Full carbon conversion at ~1000 deg C
  - No tar formation
  - Low methane formation

- **Available in large quantities**
  - World BL capacity about 660 TWh
  - Corresponds to ~ 10 billion gal gasoline equivalents per year
  - Typically 250-300 MW of BL per pulp mill
Market Potential for the Chemrec Concept
Black liquor from production of bleached and unbleached kraft pulp

Black Liquor as Dry Solids (Mton)

Black liquor from production of bleached and unbleached kraft pulp

In Sweden fuels from all Black liquor would correspond to about 25% of current diesel and gasoline consumption.

Swedish CO$_2$ emission would decrease with ~ 10%

Location for Potential Pulp Mill Biorefineries in the US

More than 100 suitable pulp mills in North America

More than 300 suitable pulp mills worldwide
Key Drivers
Well to Wheel CO2 emissions and total energy consumption for some different path ways

- Conventional gasoline
- Conventional diesel
- Biodiesel: Glycerin as chemical
- Biodiesel: Glycerin as animal feed
- Syndiesel: Coal
- Syndiesel: Natural gas
- Syndiesel: Biomass
- Syndiesel: Black liquor
- DME: Coal
- DME: Natural gas
- DME: Biomass
- DME: Black liquor
- EtOH: Wheat, straw CHP, DDGS as AF
- EtOH: Sugar cane (Brazil)
- EtOH: Wheat, straw CHP, DDGS fuel
- EtOH: Cellulose
- EtOH: Wheat straw
- EtOH: Wheat, coal CHP, DDGS fuel
- EtOH: Wheat NG GT+CHP, DDGS fuel
- Biogas: Municipal waste
- Biogas: Manure

Source: EUCAR/CONCAWE/JRC
Effective Capital Investment Intensity
$/\text{bbl per day}) \text{ vs bbl per day diesel eqiv.}
4Q, 2005 investment level

Source: Princeton, 2006
Plant Operations
Chemrec’s Booster in New Bern, NC - USA

Operates as a booster unit to the recovery boiler in the Weyerhaeuser pulp mill in New Bern, North Carolina

Corresponds to ~15% of the mill’s production

Start up: Dec 1996
Capacity: 330 tDS/day
Oxidant: Air
Pressure: Atmospheric
Op. hours: ~ 50 000

The plant is currently idle
New Bern operation data Jan – Oct 2008

Operation time [last 10 months]

- Downtime unsched. maintenance or failure
- Downtime Planned Maintenance
- Downtime external factors
- In operation

Total operation time 2008: 6 232 h
Total Calendar time 2008 (to 26th Oct) : 7 200 h
Chemrec Gasification Process
DP-1 in Piteå, Sweden

GASIFIER

Black Liquor
Atomizing medium
Oxygen

GAS COOLER

C.W
BFW
LP-St.

MP-Steam
Condensate

SULPHUR ABSORPTION
White/Green Liquor

CLEAN SYNGAS
FLARE

Weak Wash

Transforming Pulp Mills to Bio refineries

Energy to Succeed
Development Plant for Oxygen-blown high pressure BL gasification

• Located at the SmurfitKappa mill in Pitea, Sweden
• Oxygen-blown and operated at 30 bar(g)
• Capacity 20 metric tons per day of black liquor solids (3 MWth)
• Used for technical development and design verification
• Started up 2005 –Now in operation more than 11000 hours.
• Operations: 10 operators in 5 shifts
Distribution of calendar time

Rebuild to operate on sodium sulphite liquor

Accumulated operating time 10,373 h

No differentiation between planned and unplanned maintenance

Transforming Pulp Mills to Bio-refineries

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Raw gas quality from Chemrec’s DP-1 gasifier

- 50-70 ppm benzene
- < 5ppm naphthalene
- Zero or close to zero higher tars
- Very little fouling in heat exchangers
- Particulates ”non-detectable”
Project Plans
Installed Plants and Implementation Time Line

- Weyerhaeuser, USA
  - Currently idling

- Smurfit, Sweden (P20)
  - Operate
  - With DME Production

Transforming Pulp Mills to Biorefineries
THE BIODME PROJECT

Supported by:

*) The Swedish Emergency
BioDME Consortium

CHEMREC
- Plant engineering, construction and operation
- Plant owner

ETC
- Laboratory support to plant operation

BIODME
- DME distribution

DELPHI
- DME injection system development

Haldor Topsoe
- DME production technology provider

TOTAL
- DME fuel specification
- Fuel Additive development

VOLVO
BioDME Project Coordinator
- Engine development
- Vehicle manufacturing
- Field test responsible

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Energy to Succeed
Overall Scope and Objective

Demonstration of an environmentally optimized future bio-fuel for road transport covering the full chain from production of fuel from biomass to the utilization in vehicles

Starting date: 1 September 2008
Total budget: 28.4 M€ / ~ 40 MMUSD
Duration: 48 months
EU funding: 8.2 M€ / ~ 12 MMUSD
Coordinator: AB Volvo
Overall Scope Illustration

- 3G vehicle development
- Fuel injection development
- Vehicle production
- Vehicle field test
- DME Distribution & filling
- Industrial use
- Black liquor
- Biomass
- Fuel properties
- Syngas generation and cleaning
- DME production

BIO DME
Transforming Pulp Mills to Biorefineries

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Energy to Succeed
DME engine & vehicle development and production followed by Field Test

- Development and production of 14 Volvo DME trucks
- 14 Volvo DME trucks in customer operation
- Demonstrate and verify DME technology in real applications
- Planned yearly distance 100,000 km per truck (average)

**Timeline:**
- **2008** Project Start
- **2009** Dv’l’ment & Production
- **2010** Field test
- **2011** 2012
- **2013** Project End

**Locations:**
- Stockholm
- Göteborg
- Växjö
- Piteå

**Chemrec: Energy to Succeed**
Overall Scope Illustration

3G vehicle development → Fuel injection development → Vehicle production → Vehicle field test → Vehicle production

Fuel properties

Syngas generation and cleaning

DME production

DME Distribution & filling

Industrial use

Black liquor

Biomass
3rd generation DME process

First single-pass MeOH synthesis featuring high space-time yield

Source: HaldorTopsoe

Feed preparation → MeOH synthesis → CONRAD MeOH synthesis

MeOH synthesis

DME synthesis

Gases

MeOH, water

~ 4 ton DME/dag
1. Two alternatives for pipe bridge between DP1 & BioDME.
2. Area for gas treating.
3. DME –unit.
4. Day tank for DME and MeOH.
5. Pipeline to storage location of DME.
6. Pipe from AGR to incinerator at pulp mill.
7. Incinerator at SmurfitKappa.
8. Location of transformer for power supply.
9. Power room at BioDME.
10. Civil structure for BioDME.
11. Storage location for DME.
12. Occupied area for other purpose.
New BioDME Pilot CAD Illustration

- DP-1 plant
- Amine Wash
- Carbon filter
- WGS, MeOH/DME, Distillation
Illustration of the BioDME pilot

Planned production
From July 2010
Installed Plants and Implementation Time Line

Weyerhaeuser, USA
Operate
Currently idling

Smurfit, Sweden (P20)
Operate
With DME Production

Smurfit, Sweden (P500)
Design
HOLD
Construct
Oper.

New Page, USA (P500)
Design
HOLD
Oper.

Signed Feasibility Study Agreements:

2003 2005 2007 2009 2011 2013

Base for Scale-Up

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Energy to Succeed
General BLG Scheme with Key Scale up Areas

- **Air separation**
  - Oxygen
  - Power
- **Black liquor**
- **Weak wash**
- **LS Green liq.**

**Gasiﬁcation and Quench**
- Rawgas

**Gas cooling**
- Steam
- Synthesis gas

**Sulphur Management**
- Poly Sulph.
- White liquor

**Gas Purification**

**Combined Cycle** or **Synthesis- and Distillation**

**Power & Steam** or **Fuels/chemicals**

Transforming Pulp Mills to Biorefineries

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Key scale up activities

- Black Liquor
- Atomizing medium
- Oxygen
- GASIFIER
- Nozzle
- GAS COOLER
- BFW
- C.W
- LP-St.
- Raw Syngas
- Condensate
- Cleaner
- GREEN LIQUOR
- Weak Wash
- FLARE
- SULPHUR ABSORPTION
- White Liquor
- CLEAN SYNGAS

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Chemrecs Gasifiers – a comparison

Air-blown, atmospheric

- Booster, 250-330 t TS/d (type New Bern)
- FRÖVI, 50-75 tTS/d
- Piteå DP-1, 20 t TS/d

Pressurised, O₂-blown

- DP-2, 500 tTS/d (Preliminary)
Installed Plants and Implementation Time Line

- Weyerhaeuser, USA
  - Currently idling
  - Operate

- Smurfit, Sweden (P20)
  - Operate
  - With DME Production

Signed Feasibility Study Agreements:
- New Page, USA (P500)
  - Design
  - Construction
  - Operate

- Smurfit, Sweden (P500)
  - Design
  - Construction

- Industrial size plant (P1000)
  - Design
  - Construction

- Grant received from Swedish Energy Agency September 25, 2009: 500 MMSEK / ~ 70 MMUSD
- Total project cost: approx. 400 MMUSD
The Energy Combine of Örnsköldsvik
Domsjö Mill ↔ Övik Energy ↔ Övik Community
- TODAY -

Domsjö Fiber

Biomass

Pulp wood

District heat

Steam

Power

Örnsköldsvik Community

Domsjö Fabriker

A sodium sulphite based mill

Cellulose fiber
Ligno sulfonate
Ethanol

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The Energy Combine of Örnsköldsvik
Domsjö Mill ↔ Övik Energy ↔ Övik Community
- TOMORROW -

Biomass

Pulp wood

Steam

Power

District heat

Domsjö Fiber

Övik Energy

Örnsköldsvik Community

Cellulose fiber
Ligno sulfonate
Ethanol
DME/Methanol

Transforming Pulp Mills to Bioeconomies

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Complete Domsjö Mill including Fuel Production

- Cellulose fiber 800 t/d
- Ligno sulfonate 170 t/d
- Ethanol 57 t/d

DME 301 t/d or MeOH 450 t/d
Concept for development of the DME market for heavy duty vehicles

- The BioDME Project
- Domsjö Project
- Methanol - for low blend in gasoline
  - for RME/MTBE
  - for chemical use

Number of heavy duty vehicles running on DME

3Q 2010 to 2013
Biorefinery site in Örnsköldsvik
Summary and Conclusions

• Adding fuel generation to a pulp mill increases cash flow by 30-35% (without green credits).

• Fuel generation at pulp mills has in various studies shown to have highest efficiency and lowest production cost compared to alternatives.

• No quality demand on added renewable fuel. Boiler designed to cope with a large variety of biomass types.

• BL gasification opens up for new pulping cycles in the pulp mill with the potential of increased pulp yield.

• Brown field construction simplifies permitting procedures.

• Pulp mills are ideally located for large scale handling of renewable material as the logistics and systems are already in place.

• In most cases pulp mills are located where huge amounts of biomass materials are available in the proximate vicinity.
With support from and in collaboration with…

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