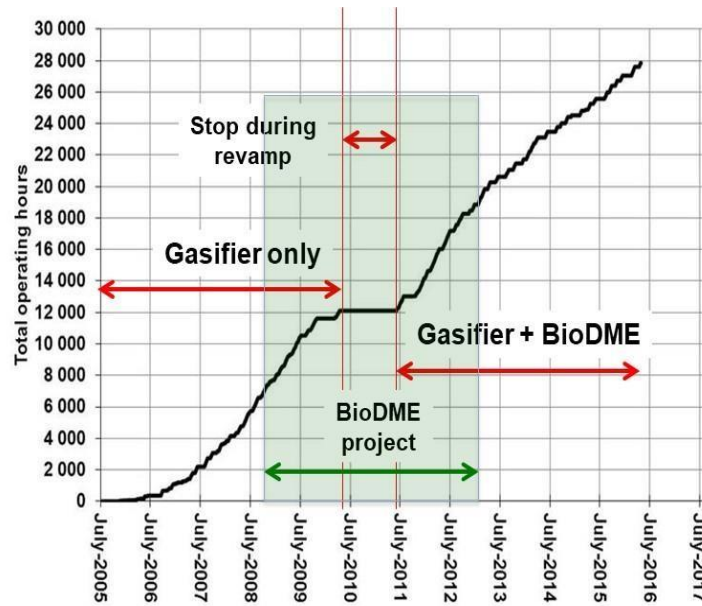


## Success Stories of Advanced Biofuels for Transport

### CHEMREC/HALDOR TOPSOE/VOLVO BIO-DME PROJECT

<b>Year of plant start-up:</b>	<p>Chemrec gasifier without downstream BioDME plant in operation from September 2005.</p> <p>Plant Start-up Nov 2011 within Bio-DME project Oct 2008 – Dec 2012</p> <p>Extended Bio-DME project Jan 2013 – Aug 2014</p> <p>Continued Bio-DME plant operation until 2016</p>
<b>Location:</b>	<p>Sweden, Norrbotten, Piteå</p>
<b>Technology:</b>	<p>Chemrec Black Liquor Gasification (BLG) Technology for production of renewable Syngas, Green Liquor and Steam for chemical recovery to the pulping process.</p> <p>Haldor Topsoe novel once through MeOH technology followed by Methanol to DME conversion technology. In included conversion of renewable Syngas from the gasification unit to (raw) Bio-MeOH and directly converting raw Bio-MeOH to Bio-DME.</p> <p>VOLVO novel DME Engine- and Vehicle Technologies for 10 Euro 5 HD trucks verified in field test.</p>
<b>Plant capacity:</b>	<p>4 ton DME/d * 300 d/y * 50 % = 600 ton DME/y</p>
<b>Total Capital Expenditure:</b>	<p>Total approx. EUR 75 million of which approx. EUR 30 million (2008-2011) for the syngas cleaning, MeOH and DME synthesis (the BioDME project) in addition to approx. EUR 45 million for the BLG plant (2001-2012).</p>
<b>Operational experience achieved:</b>	<p>The Bio-DME project accumulated approx. 7000 hours of plant operation, with approx. 400 ton BioDME produced and approx. 800,000 km field test mileage within the BioDME time period.</p> <p>Total, including Extended Bio-DME project and Continued Bio-DME plant operation until 2016, accumulated approx. 16 000 hours of plant operation, approx. 1050-ton BioDME produced and approx. 1 600 000 km field test mileage. See Figure.</p>



Accumulated operating hours 2005 to 2016 including the BioDME period 2008 to 2012

**Principle feedstocks:**

Kaft Black Liquor from Smurfit Kappa Kraftliner pulp mill in Piteå, Sweden.

An overall comment to the Chemrec concept: The Chemrec gasifier is fed with the black liquor generated as an energy rich byproduct in the pulp mill and which today is fired in the so-called recovery boiler, a central major part of the pulping process. Energy from the combustion provide steam and power for the pulp mill operation.

When the black liquor is gasified and converted to a product as described in in the BioDME project and energy thus withdrawn from the pulp mill operation, the energy needed for steam and power generation is instead fed to the plant in the form of forest residue to a high-pressure boiler. See link to FILM provided under “More 20 ton black liquor (BL) per d \*300 d/y \* 50 % = 3 000 ton BL/y secured through participation of local pulp mill in the BioDME project. 20 ton BL/day corresponds to about 3 MWth.

**Feedstock Capacity:**

**Products/markets:**

BioDME main market as transport fuel for HD trucks, buses and off-road machinery and additional industrial market through blending of 20 % BioDME into LPG.

BioMeOH by-product supplied as blend stock for RME production and chemical feedstock.

**Technology Readiness Level (TRL):**

TRL 8 – system complete and qualified

## DESCRIPTION

Application of the novel Chemrec Technology for energy- and chemical recovery from **Black Liquor (BL)** converts pulp mills to Biorefineries.

### 1. Chemrec Black Liquor Gasification (BLG) Technology.

Atmospheric Air-blown gasification:

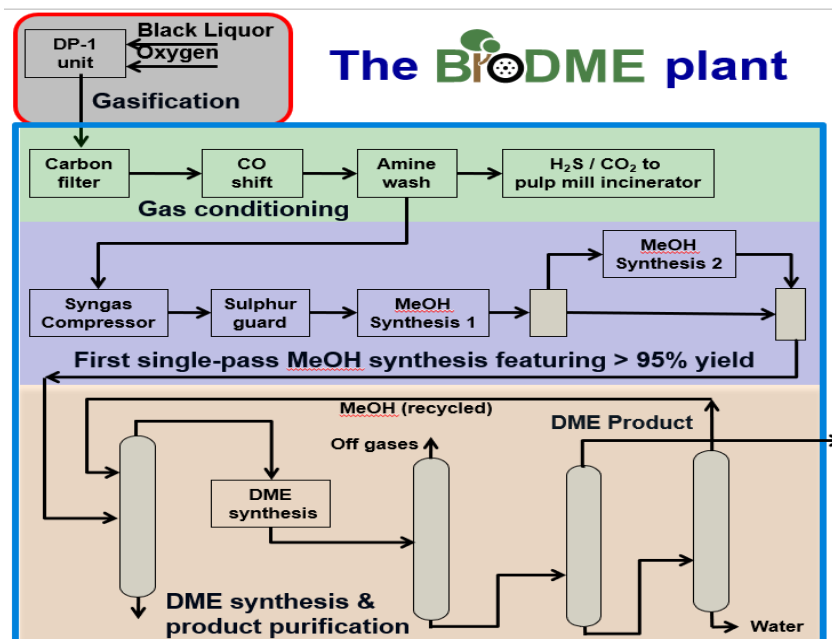
- Frövi, Sweden: 12 MWth operated about 4000 h between 1991 and 1994
- New Bern, USA: First commercial plant at Weyerhaeuser pulp mill in NC, USA. 45 MWth / 47 000 h of operation between 1995 and 2008

Pressurized, Oxygen-blown gasification

- Karlstad, Sweden: Pilot plant 1.5 MWth / 15 bar / about 1000 h of operation
- Piteå, Sweden: Development plant 3 MWth / 30 bar / about 27 000 h of operation (The BioDME gasifier unit DP-1 is per figure below). See *Figure 2 and 3*.

### 2. Haldor Topsoe methanol and DME technology

Novel once-through MeOH technology combined with conversion of raw (non-purified) methanol to fuel grade DME. See *figure below*.



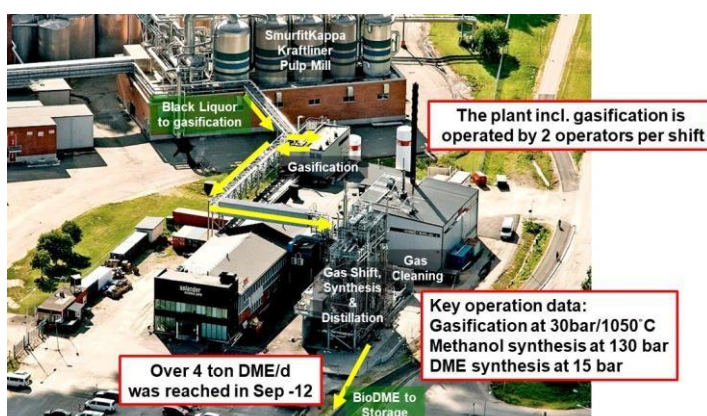
Main blocks and key process sub-units in the BioDME project. The black rectangle on top illustrates the original Chemrec gasification plant

### 3. VOLVO novel DME Engine- and Vehicle Technologies

10 Euro 5 HD trucks verified in field test. Vehicles operated in commercial services both in north and south Sweden. 4 tank station in operation and DME shipped from Piteå in a standard LPG tank car cleaned for the DME service. See *Figure 4*.

The Bio-DME project lasted from Oct 2008 – Dec 2012 and was prolonged with a national project during the period Jan 2013 – Aug 2014. After Aug 2014, LTU (Luleå University of Technology) coordinated a continued research and development program called the Biosyngas Program. Continued operation of the BioDME plant was part of that program which ended in May 2016.

During the full period Dec 2011 to May 2016 the BioDME plant produced in total 1054 tonnes of BioDME. The Volvo DME fueled trucks run in total about 1 600 000 km during that period.



View of the plant site with some key processes and data indicated.

A DME fueled timber truck operation in the Piteå area

**Stakeholders involved:**

BioDME project consortium with 17 partners incl. technology providers, forest owners and forest industry, fuel distributor, university, regional and local Government, Swedish Energy Agency.

**Financing Support:**

Direct support through grants from EU and Swedish Energy Agency.  
Indirect support through Swedish CO<sub>2</sub> tax exemption.

**Contribution to Sustainable Development Goals:**

Through utilization of Black Liquor Gasification (BLG) in chemical pulp mills, 100 % renewable feedstock from the forest is converted to sustainable renewable transportation fuels, replacing fossil fuels. In areas with significant forest and forest industries implementation of the Chemrec BLG and Topsoe synthesis Technologies represent a considerable contribution to the following SDGs: GHG emission reduction (SDG13), sustainable consumption and production patterns (SDG 12), reliable, sustainable and modern energy for all (SDG7), Sustainable use of terrestrial ecosystems (SDG15), regional development (SDG8).

**Contribution to GHG emission reduction in transports:**

Sweden produces around 25% of all forest-based pulp in the EU at around 20 different sites and the implementation of BLG and fuel synthesis at all Swedish pulp mills would replace approx. 25 % of current Swedish fuel consumption resulting in 6-million-ton fossil CO<sub>2</sub> emission savings.

Implementing the BLG technology on all European chemical pulp mills would result in 4 times larger reduction of EU GHG emissions or approximately 24-million-ton fossil CO<sub>2</sub> emission savings.

<b>Employment:</b>	<p>The Piteå plant employed 20 engineers &amp; operators. The Chemrec and Topsoe development organizations employed additional 15 qualified staff and managers.</p> <p>Each implementation project would for the development and operation phases result in plant operating and maintenance staff of about 80 people.</p> <p>According to a Pöyry study the number of indirect jobs created as a consequence of establishing a full-sized plant described in this document would be 8-10 times larger.</p>
<b>Replicability and scale-up potential:</b>	<p>The BLG/Bio-DME Technology has high replication/scale-up potential at local/regional, national as well as international level. Identified potential 70-80 plants in Europe out of 300 plants globally.</p>
<b>Success factors:</b>	<p>The key condition required for the success story to be successfully replicated is the implementation on an EU and national level is long- term (at least 15 years) stable directives and regulations which impact project cash flow, such as incentives and taxes.</p>
<b>Constraints:</b>	<p>Current lack of long-term legislation is preventive for arranging debt financing and implementation of large-scale renewable transportation fuel projects.</p>
<b>Info provided by:</b>	<p>Ingvar Landälv /Jonas Rudberg</p>
<b>More information:</b>	<p>A good description of the BioDME concept can be viewed in a 3.5 minute film produced by Volvo: <a href="https://www.youtube.com/watch?v=cF1F7luFpnc">https://www.youtube.com/watch?v=cF1F7luFpnc</a></p> <p>“Two years’ experience of the BioDME project—A complete wood to wheel concept” (can be ordered through Ingvar Landälv, <a href="mailto:ingvar@landalv.se">ingvar@landalv.se</a> or at the following link: <a href="https://onlinelibrary.wiley.com/doi/pdf/10.1002/ep.11993">https://onlinelibrary.wiley.com/doi/pdf/10.1002/ep.11993</a> )</p>



The ART Fuels Forum brings together 100 experts and leaders representing the alternative transportation fuels Industry to facilitate discussions, elaborate common positions on policy issues and identify market penetration opportunities and barriers for these fuels. The Forum is established and financed by the European Commission under the project name “Support for alternative and renewable liquid and gaseous fuels forum (policy and market issues)”.

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