

World's first Commercial Scale Biomethanol Plant in Hagfors SWEDEN

VärmlandsMetanol AB A BioMass Based Liquid Fuel Company
based on Gasification Technology
June 2011



Flygfoto: Lars Nilsson

Montage: Structor

Biomass as received	111 MW - 43 ton/h
District heat export	15 MW
Methanol energy	74 MW - 300 ton/day

Financial and technical documentation is available for potential investors subject to confidentiality agreement/non-disclosure agreements

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Background

“Without motor fuel Sweden will collapse” – that was the first of two starting points for a research project which the Miljöcentrum Foundation initiated in the early 1970s. The second starting point was that Sweden should invest in a domestic production of CO₂-neutral biomass based motor fuel. Responsible for the project was Dr Björn Gillberg, CEO and founder of the Miljöcentrum Foundation, together with the late Dr Arthur Tamplin (former head of division at the Rand Corporation and Livermore Lawrence Radiation Laboratories, California).

Initially, the study looked at how Sweden’s need of motor fuel could be met by producing ethanol through fermentation of agro-crops. However, the study concluded that agro-based ethanol only had a marginal potential to substitute petrol, simply due to the fact that there was not enough arable land around to produce the volumes needed. On the other hand, the study showed that Sweden had a surplus of forest biomass, as the annual forest growth/increment, on average had exceeded felling by 30% since the 1920s. Hence, the study suggested that a domestic production of a CO₂-neutral motor fuel should be based on forest residue and fast growing energy forest.

During the 1970s and 80s Miljöcentrum closely followed the US methanol motor fuel programmes based on gasification of coal. Technical studies, conducted by Miljöcentrum, found that the fossil based technology could be developed for the gasification of biomass in order to produce CO₂ neutral methanol. BioMethanol is an excellent substitute for petrol and can be introduced on the market as a low admixture petrol blend. The cars of today run very well on low methanol blends (up to 30 %) , more over, E85 automobiles also run on M85.

The choice to focus on bioMethanol, produced through gasification of forest biomass, was based on the fact that it is a superior liquid motor fuel in terms of energy efficiency and greenhouse gas savings, in particular compared to ethanol produced either through fermentation of agro-crops or through gasification of forest biomass.

History of VärmlandsMetanol AB

VärmlandsMetanol AB was founded in 2001 by Dr Gillberg and the Miljöcentrum foundation, with the objective to construct and operate a pilot gasification plant for the production of bioMethanol and district heat – using forest residue. The choice to locate the plant in the Municipality of Hagfors, Värmland, was based on the access to biomass feedstock and a long-standing industrial tradition (Uddeholm Tooling and other local industries). In short, Hagfors offers a favourable environment, to establish a bioMethanol Centre, for technological development and the production of components for methanol gasification plants.

VärmlandsMetanol is as of 2007 a public company. It is owned by Miljöcentrum, the Municipality of Hagfors, the Federation of Swedish Farmers, TRB (an umbrella organisation for the 12 largest haulage contractors in Sweden), 900 private persons and 30 small corporations. Euroclear Sweden maintains the register of shareholders.

In 2003 a conceptual design study was completed for a pilot plant of 21 MWth, having a yearly production capacity of 17,000 metric tons of methanol (56 percent energy efficiency biomass to methanol) and production of 4.2 MW low-grade heat for district heat. The study was accompanied by an environmental impact assessment (EIA) and a risk-assessment. The consultants who worked on the study were Nykomb Synergetics AB, Miljöcentrum, Structor AB, Geosigma AB, ATEK Mark & Miljö AB and AJ Risk Engineering AB.

Based on this initial study, the board of VärmlandsMetanol decided in 2006 to research the parameters of a large-scale facility of 100 MWth with an annual production capacity of 90,000

ton fuel grade methanol. The Finish engineering company Carbona was responsible for wood handling, gasification and gas treatment.

The result was a 111 MWth production facility, with an investment cost of SEK 2.4 billion and with an annual production capacity of 92,000 ton fuel grade methanol (58 percent energy efficiency biomass to methanol) and 12 MW low-grade heat for district heat.

Using this study as a starting point for the final design, Uhde, a ThyssenKrupp company and a world leading engineering contractor, was selected as technology supplier and engineering partner. Uhde has more than 65 years of experience with gasification technology and production of methanol – and a reference list including over 100 coal and/or oil based gasifiers, built worldwide.

VärmlandsMetanol and Uhde have signed an agreement for an Engineering, Procurement and Construction (EPC) contract. An agreement, establishing the partnership between the companies, in terms of the patents, which the project will result in, has also been signed.

In April 2010, Uhde delivered a comprehensive conceptual design and feasibility study based on a pressurised oxygen blown gasifier. When feed 111 MW forest residues the plant will annually produce 100,000 ton (126 million litre) fuel grade methanol (67-72 percent energy efficiency biomass to methanol).

Uhde is now working on a Basic Engineering Package (BEP), which includes such steps as identifying technology suppliers and together with VärmlandsMetanol enter into agreements regarding licenses for, to exemplify, the gas treatment and methanol synthesis. The BEP, will provide the technical foundation for the Front End Engineering and Design package (FEED) and the EPC contract. The first part of the BEP, the so-called pre-BEP is to be delivered in May 2011.

VärmlandsMetanol will use unrefined low cost forest residue as feedstock. Hence, the company will not compete with sawmills and paper and pulp industry for high quality wood segments. Studies carried out on the supply of feedstock/logistics show that the volumes required are at hand within a radius of 150 km. Given this perspective - transportation costs - the location of the plant in Hagfors is ideal, in particular as the flow of forest biomass from Dalarna goes right through the Municipality of Hagfors, further securing the supply of feedstock.

Other projects and co-operation for knowledge sharing

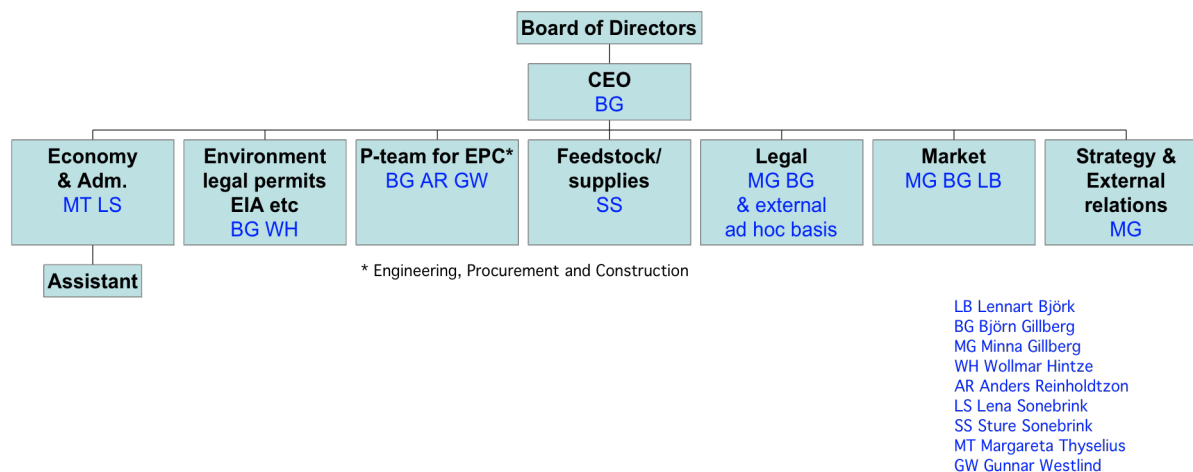
VärmlandsMetanol AB, E.ON Gasification Development AB, PEAB, Structor AB, the Municipality of Kumla and SAKAB AB have, after one year of research, decided to jointly conduct a conceptual study for a bio-refinery based on gasification of forest residue, with an annual production capacity of 250 MW bioMethane/bioMethanol and approximately 50 MW district heat. The intention is to build the plant on the premises of SAKAB's facility outside Kumla.

VärmlandsMetanol is also investigating the possibility to locate a methanol plant in connection to a large sawmill. Residues from the mill will be used as feedstock for the gasification.

Organisation and know-how for the application and project execution

VärmlandsMetanol has during the initial phase of the project worked with a flat and needs-based organization, drawing on VärmlandsMetanol's noteworthy in-house competence, with a few but highly skilled employees who have worked closely with consultants from Uhde and Vattenfall Power Consultants. For financial projections VärmlandsMetanol has engaged *PwC* (formerly known as *PriceWaterhouseCoopers*).

Currently, VärmlandsMetanol has a staff of five working full time with the project. Within the organization of Uhde, approximately 20 engineers are working full or part time with the project. It should also be noted that VärmlandsMetanol's Board of Directors have impressive track records. Members have been chosen based on their skills relevant to the project and they work actively with different parts of the project. The chart below describes the current organization.



The CEO and driving force behind the project is **Dr Björn Gillberg** who has worked with R & D on gasification technology since 1975 in partnership with the late Arthur Tamplin, Ph.D., a noted biophysicist (former head of division at the Rand Corporation and Livermore Lawrence Radiation Laboratories, California).

Dr Gillberg is a legendary Swedish environmentalist often called the godfather of the Swedish environmental movement. He has been an advocate of production of bioMethanol since the 70s. Dr Gillberg is a chemist.



Dr Gillberg has also successfully acted as Environmental Controller for two of the largest construction projects ever carried out in Scandinavia (such as the SEK 17 billion Öresunds Bridge between Sweden and Denmark, and the SEK 9 billion project City Tunnel in Malmö, Sweden). Dr Gillberg has received several honorary awards for his long lasting service to the environment such as the IKEA stitching foundation prize. In 1991 he was elected to the UN 500 Global

Roll of Honour and in 1999 he received an honorary doctorate at Lund University, Sweden. Together with his wife, Marianne, Dr Gillberg owns 47,058 A-shares and controls 94,118 A-shares through the Miljöcentrum Foundation.

VärmlandsMetanol's Board of Directors can show an impressive track record. Members have been chosen based on their skills and major accomplishments in different sectors relevant to the project. **Chairman of the Board of Directors** is the distinguished businessman and entrepreneur **Lennart Björk**. He started his career as an electro-engineer and then went on to create the highly successful clothing company GANT, which now has a global turnover of SEK 8 billion. In 2008 he sold the company but he has remained active in the company as Chairman of

the Board, a position he also holds in the companies Boomerang and New Moon. Together with his wife Ulla, Lennart Björk owns 250,000 B-shares in VärmlandsMetanol.

Other distinguished **Members of the Board:**

Dr. Wollmar Hintze - is a civil engineer with a broad experience as technical consultant and CEO. Between 1986-1997 he worked as CEO for Scandiaconsult Miljöteknik AB and then, 1997-2002, he served as Environment Director for Scandiaconsult Group. In 2002 he took up the position as Environment Director for the SEK 9 billion Citytunnel project in Malmö, Sweden. Dr Hintze also acts as an adviser to Tetra Pak on environmental issues relating to process technology. He owns 3,000 B-shares in VärmlandsMetanol.

Mr. Börje Lagerqvist - is a farmer and the distinguished Chairman of the Board of Directors for Mellanskog - a business organization for 26,000 private forest owners who in total control 1.8 million hectares of Swedish forestland He is also a board member of Fryksdalens Sparbank and LRF Skogsägarna (the Federation of Swedish Forest Farmers) which is an interest and business organization with 111,000 members, who together owns more than 6 million hectares of forestland. Mr. Lagerqvist does not own any shares in VärmlandsMetanol and is to be considered as an independent board member.

Mr. Sture Sonebrink is an entrepreneur active in the forest industry. Mr Sonebrink is one of the co-founders of VärmlandsMetanol. He is also the owner of one of the largest private forest companies in the county of Värmland. Mr. Sonebrink owns personally and through his companies 94,118 A-shares and 6,033 B-shares in VärmlandsMetanol.

Dr Mina Gillberg* works as Strategic Adviser to VärmlandsMetanol. Dr Gillberg has served as adviser on sustainable development, renewable energy and climate change to the EU Environment Commissioner and Vice President of the European Commission, Margot Wallström and also to Gro Harlem Brundtland, former Norwegian Prime Minister and Special Climate Envoy to the UN General Secretary. Prior to these positions, she held a research fellowship at Oxford and Lund University and also worked as adviser to European Governments and corporations. Dr Gillberg owns 3,000 B-shares in VärmlandsMetanol.

VärmlandsMetanol has engaged some highly experienced individuals who have managed and executed industrial and infrastructural projects of major scale. **Mr. Reinholdtson** (MSc in Chemical Engineering) has an impressive track record with Vattenfall Power Consultants. He has many years of experience working with project financing and as project director for gas power plants and as project manager for industrial projects of major scale such as air separation units and gasification of coal, oil and biomass.

The future project organization will grow organically based on needs arising as the project progress. During the construction phase, which is the most labour intense, the organization must mirror Uhde's EPC organization. This means that for the duration of this phase (3 years), VärmlandsMetanol must increase the number of employees to approximately 30. Subsequently, when entering into the production phase, management will be downsized to a minimum, employing some 50 plant-operators and a plant manager with a small administrative team. The most important function in the organization will be that of the feedstock purchaser. However, to be noted is that VärmlandsMetanol already has entered into a product off-take agreement and into feedstock purchase agreement with a major operator on the Swedish market.

***Deputy Board Member**

Capital requirements/financing

As of April 2011 the cost for the plant – an EPC-contract - is estimated to some SEK 3 billion (EUR 300 million). To be added to this sum are license fees and owners costs.

The project has in so far been financed by private equity and shares have been issued step by step according to financial needs. The financial strategy is to raise 50% of required capital through private equity and the remaining 50% through bank loans.

Time schedule and project plan

The time plan for the project starts running 1 January 2011 with a test operation scheduled to commence during the last quarter of 2014.

The project's positioning in the "innovative chain"

Drawings from coal based gasification technology, VärmlandsMetanol and Uhde, have joined forces to develop a unique biomass based gasification concept, which involves several innovative steps.

It should be noted that crushing the biomass is a particularly energy intensive (electricity) process. VärmlandsMetanol has initiated tests of a new technology, which if it delivers on its promises, considerably will reduce the electricity consumption for the crushing.

Legal permits

Permits are required according to the Swedish Environmental Code and the Municipal Planning and Building Act. A number of various regulations and laws also apply in connection with construction and erection of the plant and operation.

Based on a comprehensive Environmental Impact Assessment (EIA) accompanied by a technical description and a risk assessment, a 20 ha property has been purchased for the location of the plant. The above mentioned documents are part of a detailed development plan that has been prepared for the site. Studies on the impact on landscape and flow of traffic have also been concluded. As a result, an agreement has been made between VärmlandsMetanol, the Municipality of Hagfors and the Swedish Transport Administration regarding financing of changes required to road 246 in order to ensure road transportation safety to and from the site. The total cost for the reconstruction roadwork is SEK 8 million.

The above mentioned detailed development plan has been adopted according to the Municipal Planning and Building Act and entered into force 25 January 2010. A building permit will be applied for, once the environmental permit has been obtained. In this context, the application for a building permit is a formal matter of less significance, given that the detailed development plan for the site already has been adopted and entered into force.

The existing EIA, technical description and risk assessment is currently being revised according to the environmental code and the requirements of an extended EIA. The extended EIA was initiated spring 2010 whereby consultations have been held with the municipality of Hagfors, the concerned public and concerned authorities such as the Country Administrative Board, the Swedish Environmental Protection Agency and the Swedish Civil Contingencies Agency. The consultation process was concluded 4 October 2010.

Consultation documents, such as protocols and opinions, will together with the EIA, the technical description, the risk assessment and an application for a permit according to the Environmental Code will be submitted to the environmental court in Vänersborg before the end of August 2011.

The permit and stipulated conditions are then expected to be issued by the court during the end of 2011. Site preparation works will commence once all permits have been granted and entered into force.

Summary – why gasification of biomass for methanol production?

In a Swedish context a large-scale investment in gasification technology for the production of biofuels is a realistic cost and energy efficient way forward to reach the EU 10% target for renewable motor fuels by 2020. We have the forest residue. The infrastructure for methanol as low blend admixture in petrol is already in place, which paves the way for a significant, cost-efficient and immediate reduction of CO₂ emissions from the existing and future automobile fleet.

Methanol burns cleaner and more efficient than any other liquid motor fuel. More over, methanol is superior to ethanol and other, at normal air pressure, liquid long chained hydrocarbons for fuelling fuel cells in electric vehicles.

The choice of bioMethanol produced through gasification, as a substitute for petrol, is from a process and technological perspective, self-evident. The energy efficiency (gasification of biomass to methanol) is higher than for any other liquid motor bio fuel. This is explained by the fact that the methanol molecule only has one carbon atom and because the energy efficiency/yield decreases when long chained hydrocarbons are synthesized.

More over, the Swedish automobile industry has confirmed that the petrol-fuelled cars of today, without any problems, can run on petrol with a low blend methanol admixture. The Swedish petrol companies are also positive to introducing methanol on the market as a low blend admixture in petrol.

“Another alternative motor fuel is methanol, which commonly is referred to as wood-alcohol. Just as ethanol it is excellent to use as a low admixture in ordinary petrol. Another advantage is that it is cheap to produce from wood biomass. It is difficult to find disadvantages with using methanol. There is a surplus of biomass feedstock and the infrastructure – the gas stations – already exist”.

Source: Swedish Preem, the Energy Challenge 2010

The time is more than ripe for a commercial project of industrial scale for the production of methanol through gasification of biomass. VärmlandsMetanol's industrial partner Uhde, is one of the very few global actors, having the competence, the experience and the financial “ muscles” needed to guarantee a successful implementation of the project.