World´s first Commercial Scale Biomethanol Plant in Hagfors SWEDEN

VärmlandsMetanol AB A BioMass Based Liquid Fuel Company

based on Gasification Technology
April 2017

Flygfoto: Lars Nilsson Montage: Structor

Biomass as received 111 MW - 43 ton/h
Methanol energy 74 MW ≈ 315 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 CO_2-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 CO_2-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 CO_2 neutral methanol. BioMethanol is an excellent substitute for petrol and can be introduced on the market as a drop-in fuel in petrol. The cars of today run very well on blends as high as 30 volume percent (M30), 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. BioMethanol is also be used for production of biodiesel (100%) by esterification of different vegetable oils. Furthermore, BioMethanol is a basic building block for hundreds of chemical products. It is, moreover, and ideal fuel for fuel cells.

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 companies in Sweden), 1500 private persons and 30 small corporations. Euroclear Sweden maintains the register of shareholders.

In 2003 a conceptual design study was completed for a 21 MWth pilot plant, 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, ThyssenKrupp Industrial Solutions (former ThyssenKrupp Uhde), a world leading engineering contractor, was selected as technology supplier and engineering partner. ThyssenKrupp Industrial Solutions (TKIS) 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 ThyssenKrupp Industrial Solutions have signed an agreement for an EPC contract (Engineering, Procurement and Construction). 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, ThyssenKrupp Industrial Solutions delivered a comprehensive conceptual design and feasibility study based on a pressurised oxygen blown gasifier. When feed 111 MW forest residue the plant will annually produce 107 000 ton fuel grade bioMethanol. The energy efficiency biomass to methanol will be 67 percent.

The first part of the Basic Engineering Package (BEP), the so-called pre-BEP, was delivered in August 2011. Selection of process technology providers/licensors took place during 2012. License agreements have been negotiated and finalized as well as the design basis document.

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.

The enormous amount of engineering and development efforts of all tecknical and commercial information from the Hagfors project is proprietary to VärmlandsMetanol and TKIS. The lead time for this kind of project is approximately 10 years of which 7 years have been carried through in the Hagfors project. VärmlandsMetanol and TKIS are as business partners committed to apply the wealth of existing engineering work for fast-track project realization of biomethanol plants world wide.

Business plan

A primary business objective is to develop a “turnkey” concept in cooperation with TKIS and build additional plants in Sweden and other forest rich countries.

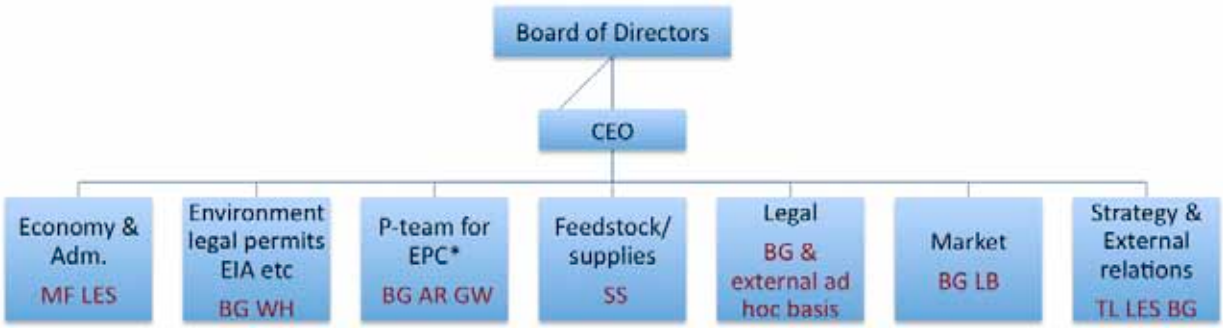
VärmlandsMetanol AB, E.ON Gasification Development AB, PEAB, Structor AB, the Municipality of Kumla and SAKAB AB, after one year of research, decided to jointly conduct a conceptual study for a bio-refinery based on gasification of forest residue, with an annual production capacity of 250 MW bioMethane/bioMethanol and approximately 50 MW district heat. The intention is to build the plant on the premises of SAKAB’s facility outside Kumla. The study was completed in September 2013.

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

At present discussions are taking place with a Canadian consortium to jump-start a biomethanol plant in the province of Quebec.

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 ThyssenKrupp Industrial Solutions and consultants from Pöyry SwedPower (former Vattenfall Power Consultants). For financial projections VärmlandsMetanol has engaged *PwC* (formerly known as *PriceWaterhouseCoopers*).

Currently, VärmlandsMetanol has a staff of three. Within the organization of TKIS, approximately 20 engineers have been engaged full or part time in 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.



* Engineering, Procurement and Construction

LB Lennart Björk
MF Monica Fredriksson
BG Björn Gillberg
WH Wollmar Hintze
LS Torbjörn Lindskog
AR Anders Reinholdtzon
LES Lena Eriksson Sonebrink
SS Sture Sonebrink
GW Gunnar Westlind

Members of the Board
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 for 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 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 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 **Dr. Wollmar Hintze.** He 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. Torbjörn Lindskog is a graduate from Handelshögskolan in Gothenburg, School of Business, Economics and Law. During the 1970- and 80-ties he worked as export manager at Edsbyns Industri AB, Haglund&Söner and TVAB. He continued as export manager at Electrolux AB in Arvika and was appointed CEO at Elektromekan i Årjäng AB. In 1996 he became CEO at the manufacturer of high precision ammunition, Norma Precision AB in Åmotsfors until he retired 2013. Torbjörn Lindskog is a member of the board of Westmatic AB i Arvika, Lennartsfors AB and Norma Precision AB. He is chairman of the board of Westmatic Corporation, Buffalo NY, USA and Aircoil AB in Årjäng. Torbjörn Lindskog has no shares in VärmlandsMetanol.

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 7 667 B-shares in VärmlandsMetanol.

Others
VärmlandsMetanol has engaged some highly experienced individuals who have managed and executed industrial and infrastructural projects of major scale. **Mr. Anders Reinholdtzon** (MSc in Chemical Engineering) has an impressive track record with Vattenfall Power Consultants and Pöyry. 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.

Mr. Lennart Björk is a former Chairman of the Board of Directors of VärmlandsMetanol and is now acting as a senior adviser. 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 remained active in the company as Chairman of the Board until 2012. Together with his wife Ulla, Lennart Björk owns 250 000 B-shares in VärmlandsMetanol.

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 TKIS'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 agreements for purchase of feedstock with two major operators on the Swedish market.

Capital requirements/financing
As of December 2016 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
Within TKIS´s comprehensive pre-Basic Engineering work, a project execution plan has been developed. The plant can be ready for startup within 36 months provided that the capital is secured as of to date.

The project's positioning in the "innovative chain"
VärmlandsMetanol and ThyssenKrupp Industrial Solutions, 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.

Project execution - status
VärmlandsMetanol has completed a significant part of the necessary legal and technical preparatory work.

- an **Environmental Impact Assessment** (EIA) and a **Risk Assessment** has been completed as required by the Municipal Planning and Building Act and the Swedish Environmental Act
- based on the **EIA** a **20 hectare property** for the construction of the plant has been acquired
- a detailed development plan for the site has been approved 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 has already been adopted and entered into force.
- an **advanced conceptual design and feasibility study**, presented to VM in April 2010 by **TKIS**, proves the technical and economic viability of the project (TKIS's study was preceded by two conceptual studies)
- **supply of feedstock has been secured** – letters of intent have been signed **with Mellanskog and Sveaskog** (leading producers of forest feedstock in Sweden) **and with one of the largest sawmills** in the region
- the existing EIA, technical description and risk assessment has been 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.

  Consultation documents, such as protocols and opinions, together with the EIA, the technical description, the risk assessment and an application for a permit according to the Environmental Code have been produced in-house and will be submitted to the environmental court in Vänersborg. Site preparation works will commence once all permits have been granted and entered into force.
- in July 2010, **VM** and **TKIS** agreed to commence with the project realization by entering into the engineering phase. A **pre-Basic Engineering Package** (pre-BEP) was delivered September 2011
- **VM** has selected **TKIS** as **EPC contractor** - **MoU** to this effect was signed in December 2010
- **license agreements** with different technology providers has been negotiated and finalized in 2012

- **D**esign **B**asis **D**ocument finalized in 2012
- **off-take agreement** with an oil-company and two international chemical corporations is currently being discussed
- **VM** has developed and initiated a **long term business strategy**:
  - completed a conceptual study for a **2nd plant** in co-operation with **E.ON**
  - concluded an agreement for a **3rd plant** in co-operation with a **sawmill**
- The project delayed due to unexpected CO_2- and energy taxes on biofuels since 2013
- No tax on biomethanol as of January 1, 2016
- Start-up 36 months after securing capital

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 as well as the Swedish target - a fossil free transportation system by 2030. We have the forest biomass. The infrastructure for methanol as low level blend in petrol is already in place, which paves the way for a significant, cost-efficient and immediate reduction of CO_2 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 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.

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

Methanol is also a basic building block for hundreds of chemical products. Methanol ranks among the top 4 globally used chemicals. It is used safely and effectively in everything from plastics and paints, to construction materials and windshield washer fluid. It is the principle ingredient in various organic chemicals such as formaldehyde, acetic acid, chloromethane and methyl tertiary butyl ether (MTBE). Further more, methanol is used for denitrification in municipal waste water treatment plants and can be an excellent turbine fuel for electric power generation. Methanol is also an ideal hydrogen carrier fuel for fuel cell technology applications.

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 TKIS, 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.