

World's first Commercial Scale Biomethanol Plant in Hagfors SWEDEN

VärmlandsMetanol AB A BioMass Based Liquid Fuel Company

based on Gasification Technology
March 2012



Flygfoto: Lars Nilsson

Montage: Structor

Biomass as received	111 MW
District heat export	15 MW
Methanol energy	74 MW \approx 300 ton/day

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

For further information, contact Dr Björn O. Gillberg and/or see: www.varmlandsmetanol.se
Address: Postbox 61, SE-683 22 Hagfors, Sweden
Telephone: +4656316560 E-mail: info@varmlandsmetanol.se

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), 1 200 private persons and 50 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 (www.uhde.eu/en.html).

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 residue the plant will produce 100 000 ton (126 million litre) or, alternatively 110 000 ton (138 million litre) fuel grade bioMethanol depending on the choice to deliver, or not deliver, 15 MW district heat to the Municipality of Hagfors. The energy efficiency biomass to methanol will be 66 alternatively 72 percent.

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 was delivered in August 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.

BioMethanol – a superior CO₂ neutral liquid motor fuel

Methanol is the simplest form of all alcohols - CH₃OH - also known as “wood alcohol.” Methanol can be produced from any carbon-based source. These would include: natural gas, coal, municipal wastes, landfill gas, wood wastes and seaweed. Fossil-based methanol is primarily produced from synthesis gas. The so-called “syngas” is fed into a reactor vessel where it is cleaned and enriched in hydrogen through a shifting reaction and then catalytically converted into methanol. When producing bioMethanol, the main technical difference is that biomass is used as feedstock, instead of coal or natural gas. BioMethanol produced through gasification of cellulosic biomass is a superior liquid motor fuel compared to other CO₂ neutral liquid fuels:

- **Fuel properties are excellent** due to the high octane rating; it burns with very clean fumes and can be used in spark ignition port injected gasoline engines blended with gasoline (up to 25%) without any modification. So-called flexi fuelled vehicles (FFVs) made for E85 can also run on high methanol blends, such as M85.
- **BioMethanol can be introduced** on the market by **using present distribution systems** without additional costs.
- **Greenhouse gas savings** exceed other liquid bio-fuels by far, 80-90% in comparison to 15-40% for agro-based ethanol.
- **The cars of tomorrow** will have electric motors powered by **fuel cells** - bioMethanol is the most cost-efficient and environmental friendly liquid fuel for fuel cell vehicles. Methanol can be directly fed into a fuel cell without being reformed into hydrogen.
- **Contrary** to oil and gasoline, **methanol is safe to handle** – it is not mutagenic or carcinogenic, it degrades rapidly in soil, surface and ground water and burning methanol is extinguished with ordinary water.

Market drivers – EU legislation and tax exemptions

The European Union’s (EU) biofuels market largely depends on consumption mandates and incentives. The main emphasis of these measures is clearly on the consumption side. The EU’s energy and climate strategy stipulates in Directive 2009/28/EG that 10% of all motor fuels shall be renewable by the year 2020.

The Directive is an efficient market driver and a clear indicator for investing in second-generation bio fuels, such as bio-methanol produced through gasification of cellulosic biomass. By defining stringent default values for greenhouse gas savings, the Directive will in practice lead to the phasing out of agro based first generation ethanol between 2016 - 2020.

According to regulatory framework in Sweden gasoline is taxed with an energy and a CO₂ tax (in total SEK 5.50 per litre, excluding VAT). In order to promote renewable fuels, CO₂ neutral fuels, such as bioMethanol are exempt from these taxes by law (at least until 2030).

Potential market share and off-take agreements

In a Swedish context, the implementation of the EU Directive 2009/28/EG means that, on an annual basis, 500 000 m³ of gasoline and 500 000 m³ of diesel must be substituted by second generation renewable fuels. The production capacity of VärmlandsMetanol AB - the plant in Hagfors - will on an annual basis amount to ca 130 000 m³ of fuel grade bioMethanol, replacing 130 000 m³ of gasoline when low blended (this figure would increase to 260 000 m³ if the cooperation project with E.ON to build a second plant is realized). As an early and first mover VärmlandsMetanol will hold an exclusive market position in Sweden and Europe as producer of bioMethanol - VärmlandsMetanol is currently formalizing an off-take agreement with an oil-company.

More over, with climate change being high up on the political and business agendas, a growing consumer demand on carbon footprinting (labelling of products and services), the introduction of a carbon footprint standard (ISO 14067) and the inclusion of methanol in the EU Emission Trading Scheme another huge market is opening up for bioMethanol - namely, the European chemical industry.

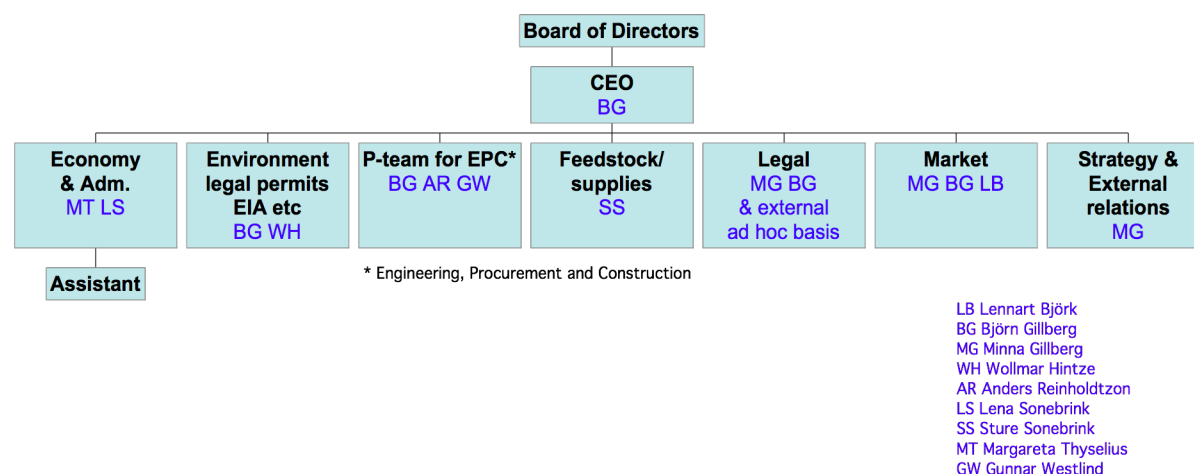
The EU chemical industry is the major importer, producer and consumer of fossil based methanol. Methanol is a basic building block for hundreds of chemical products and methanol ranks among the top 4 globally used chemicals. The total methanol demand in the EU is 9.6 million metric tons and the current import is about 6 million metric tons. At present global methanol production capacity stands at about 45 million metric tons per year. The heavy dependency on fossil hydrocarbons, high oil and gas prices and growing consumer demands for a lighter carbon footprint have led the chemicals industry to explore possibilities to widen its feedstock base, in particular by broader use of bio-based renewable raw materials such as bioMethanol.

Against this backdrop, international corporations, such as AkzoNobel and the Perstorp Group are now seriously looking to replace fossil feedstock with biobased raw materials, such as bioMethanol with a view to improve their carbon footprint. VärmlandsMetanol has been approached by a number of chemical corporations, which have expressed an interest in purchasing the bioMethanol the plant in Hagfors will produce. To further secure product off-take, VärmlandsMetanol has negotiated preliminary agreements with two of these international chemical corporations.

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 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 Arthur Tamplin, Ph.D., a noted biophysicist (former head of division at the Rand Corporation and Livermore Lawrence Radiation Laboratories, California and the Natural Resource Defence Council, Washington D.C.). 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.



Björn Gillberg (CEO) and Lennart Björk (Chairman)

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. 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 (*Deputy Board Member*) 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.

Mr. Börje Lagerqvist - is a farmer and 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 (a regional bank) 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 has been an independent board member and is now acting as a senior advisor.

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.

Owners

VärmlandsMetanol AB is a public company, which was founded by Dr Björn Gillberg and the Miljöcentrum foundation. Today the company is owned by the founders, 1 200 private persons and 50 small corporations. VärmlandsMetanol AB is affiliated to Euroclear Sweden.

VärmlandsMetanol AB has issued 1 204 829 shares. The issued share-capital is SEK 1 204 829. There are 400 000 A-shares (one vote per share) and 804 829 B-shares (one tenth of a vote per share). The B-shares were issued twice in 2007 (at a price of SEK 30 and of SEK 37.50), once in 2008 (SEK 50), once in 2009 (40 SEK), once in 2010 (60 SEK) and once in 2011 (60 SEK).

The largest owners are represented as follows:

A-shares

The Miljöcentrum Foundation	94 118
Jan Bernander	94 118
Marianne and Björn Gillberg	47 058
Forest Company Sture Sonebrink	80 000
Sture Sonebrink	14 118
The Municipality of Hagfors	47 058
LRF, Lantbrukarnas Riksförbund	23 530
(the Federation of Swedish Farmers)	

Total A-shares 400 000

The B-shares are owned by 1 200 private investors and 50 companies (one of these companies notably being TRB, which is an umbrella business organization for transportation/logistics agencies with an annual turnover of SEK 12 billion, operating in total over 7 400 lorries). Lennart Björk, founder and chairman of GANT, owns together with his wife Ulla Björk, the single largest post of B-shares, 250 000 shares.

Capital requirements/financing/return

As of December 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.

When looking at the total production cost, volume and sales price, including such factors as forecasted price for oil, methanol, electricity, feedstock, process chemicals, insurance, maintenance, labour costs and a 5% interest rate - the figures indicate that at **full production – production year 3** - the Hagfors plant will generate a promising return on capital.

Time schedule and project plan

The time schedule for the project starts running 2012 with test operation scheduled to commence during the last quarter of 2015.

The project 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 and Uhde have 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. In April 2010, Uhde presented a **conceptual design and feasibility study**, which proves the technical and economic viability of the biomass gasification plant. Based on this study Uhde has been contracted to deliver a **Basic Engineering Package (BEP)**, of which the first part was delivered in August 2011. As of date, the following preparatory work has been completed:

- 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 **Uhde**, proves the technical and economic viability of the project (Uhde's study was preceded by two conceptual studies).
- **supply of feedstock has been secured** – letters of intent have been signed **with Mellanskog** (a leading producer of forest feedstock in Sweden) **and with one of the largest sawmills** in the region

- 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. The permit and stipulated conditions are then expected to be issued by the court in 2012. Site preparation works will commence once all permits have been granted and entered into force

- in July 2010, **VM** and **Uhde** agreed to commence with the project realization by entering into the engineering phase and Uhde was contracted for a **pre - Basic Engineering Package** (pre-BEP) that was delivered August 2011
- **VM** has selected **Uhde** as **EPC contractor - MoU** to this effect was signed in December 2010
- **off-take agreement** with an oil-company and two international chemical corporations is currently being negotiated
- **license agreements** with different technology providers has been negotiated and will be finalized in January 2012
- **VM** has developed and initiated a **long term business strategy**:
 - conducting a pre-feasibility concept study for a **2nd plant** in co-operation with **E.ON**
 - concluded an agreement for a **3rd plant** in co-operation with a **sawmill**

Forest residue as feedstock

Forest residue (GROT) is a “bi-product” from commercial logging and consist of small trees, branches, tops and roots left in the forest after the cleaning, thinning or final felling of forest stands. Today most of the GROT is left to decompose for obvious reasons i.e. forest residue has a limited value as industrial feed stock for the pulp and paper industry and when used as energy fuel, it is also limited due to the increasing transportation costs that comes with distance.

VärmlandsMetanol will use unrefined low cost forest residue (GROT) as feedstock and thereby contribute to the creation of a new market segment in the forest fuel business area. Hence, VärmlandsMetanol will not compete over resources with traditional market actors, such as sawmills and the paper and pulp industry.



GROT

The methanol production of VärmlandsMetanol will require 0.9 TWh of cellulosic biomass per year. A recent report from the Swedish Forest Agency concludes that at least 5.87 TWh of forest residue (GROT) is available for annual out take, only in the county of Värmland (Projekt SWX-Energi, Report nr 16, April 2011, Potential för skogsbränsle i Värmland – hinder och möjligheter).

VÄRMLAND – standing volume, increment and felling *

	Million m ³ fub	Million tons	TWh
Standing volume	198	159	398
Annual increment	8.2	6.6	16.5
Annual felling	5.2	4.2	10.5
Annual consumption VärmlandsMetanol	0.4	0.352	0.88

* these figures do not include GROT

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.