Shades of green

The dream of a sustainable and economically viable green biomass-based fuel for use in combustion engines is coming closer and closer to reality. This shift is guided by a mix of government directives and incentives. By 2020, so the EU stipulated on 15th February 2007, all cars must use a 10 percent blend of ethanol with petrol or methanol with diesel. The processes used to produce these two components differ in that ethanol uses fermentation to produce alcohol and methanol is produced using a gasification process to produce a raw but clean synthesis gas that is processed into biodiesel.

Today Brazil is already surpassing the EU 2020 goal of blending by using ethanol derived from sugar cane. As early as 1925, ethanol was produced and by 1975 a program was introduced that had by 1993 led to a 20 to 25 percent mix. This huge country has 313 ethanol plants in operation and, with export in mind, an additional 89 plants are planned. Biodiesel is also on the rise using palm oil or soybeans as raw materials. The existing 10 plants will soon be joined by 100 more.

The USA is using corn and wheat to produce ethanol on an increasing scale and in Europe experiments are ongoing with ethanol production from grain, sugar beet and vegetal cellulose from sources such as grass, tree branches, roots and stumps. Better economics are obtained with new combined plants. Waste products from ethanol production are used to produce methanol for bio diesel. The pulp and paper industry in Sweden is currently successfully testing gasification of black liquor to produce bio diesel. Another green source of vehicle fuel used in some countries is methane gas derived from mixed refuse which is used in cities to drive fleets of buses and small trucks.

Raw material for these different fuels will of course depend on the availability in the given area. However, will they all be sustainable, green and economically viable? The jury is still out and many shades of green show up when a strict analysis is made. For example some years ago the Dutch government decided to make biofuel from imported palm oil. On the surface, this looked very viable and truly green. A recent study revealed the consequences of the increased demand: Rain forests in South East Asia were burnt down producing massive amounts of CO_2, and replaced by palm oil trees needing fertilizers. Considering the global perspective, this Dutch initiative did not look so green any more. The greenness of a process can often only be judged when the entire production chain is taken into account.

Many biofuel technologies are being jump-started through governmental incentive programmes. In the long run, however, they must be able to stand on their own feet economically.

To be both truly green and financially viable, the process must be sustainable in all respects and a net contributor to the reduction of CO_2 emissions. Many processes currently in operation will not pass such rigorous test criteria, but some will, and it is these winners that will provide the green future we are dreaming of.

Biogas from waste

Two interesting biogas facilities were taken into production in Sweden in late 2006. The cities of Boras and Gothenburg are leading the battle against global warming by powering their fleets of trucks, buses and other vehicles with bio methane produced from the mixed refuse from domestic and industry's dustbins. The increasing interest in reducing carbon dioxide emissions in the transportation sector has created opportunities and incentives to convert to "green" cars using tax and duty reductions including free parking in the big cities of Sweden. Biogas production is rapidly being established as an alternative to fossil-based fuels.

The processes used in these two cases are supplied by Läckeby Water, a privately held company from southern Sweden. The equipment provided by this company consists of drum sieve modules, heat exchangers, filters, decanters and sand washers. These are combined into a process tailored to match the specific requirements defined by the available input mixture. The produced biogas is cleaned by the special Cooab technique, which emits as little as 0.1 percent of the methane into the atmosphere (other methods release two to four percent). Besides the reduction in greenhouse gas emissions, this means that more energy is converted into useful biogas.

The Boras and Gothenburg installations will, at full production, produce 25 GWh and 60 GWh per year respectively.

ABB's involvement with these two facilities consists of the supply of the automation system and electrical equipment such as motors, drives and switchgears. Through its participation in biogas projects of this type, ABB's engineers have developed know how that can be packaged into modular applications for reuse. Today, Sweden is the world leader in bio methane production for vehicles, hence application know how is at the forefront of development.

The Boras and Gothenburg installations will, at full production, produce 25 GWh and 60 GWh per year respectively, with that at Gothenburg representing the world's largest facility for biogas. Gas from the decomposition of biological refuse is washed and cleaned to provide bio-methane for the municipality's vehicle fleet. The corresponding reduction in CO_2 emissions is estimated to be more than 20,000 tons annually.

The process supplier, Läckeby Water, has supplied 4000 projects of different magnitudes to 68 countries around the globe. Encouraged by tax incentives, the sale of biogas-powered cars increased by 50 percent in 2005 growth that creates new opportunities for Läckeby Water and ABB. It is estimated that further installations in Sweden will, by 2020, create employment for 60,000 people, which equates to the manufacturing jobs lost during the last five years. This expansion is hence both environmentally and politically rewarding.

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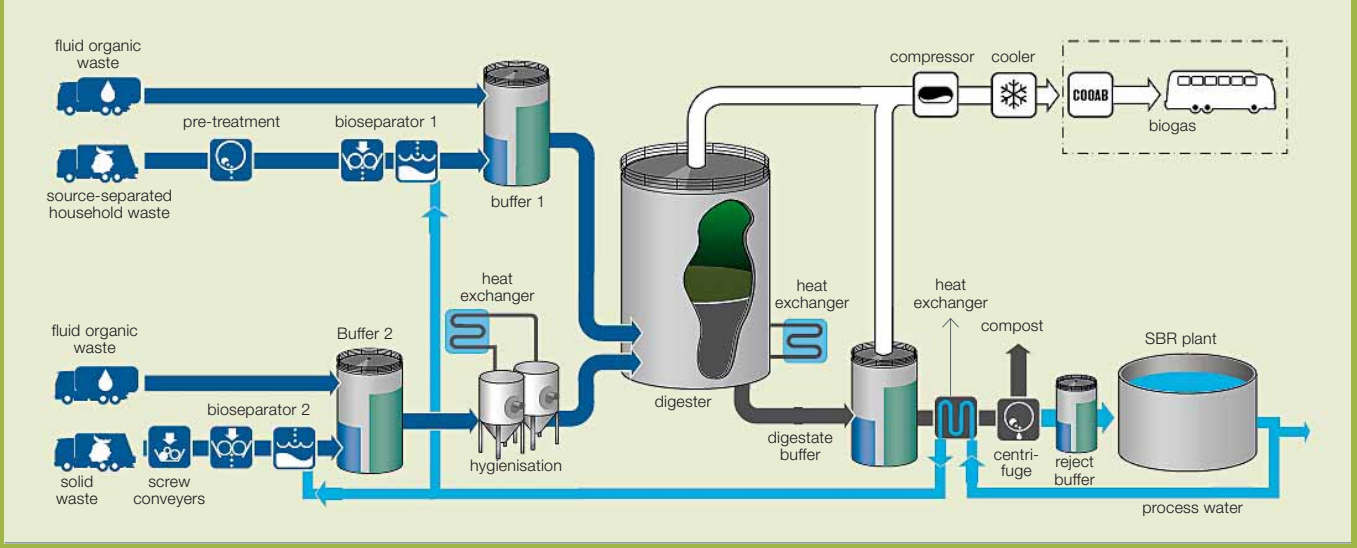
The Sobacken generation 2 biogas plant



Ethanol: Under royal guidance

The production of biofuels is being pursued in Thailand as a substitute for oil and natural gas. Developments are focusing on the active use of cheap organic matter. In fact, the production of gasohol (a blend of ethanol and premium petrol) in Thailand originated with the royal project of His Majesty King Bhumibol Adulyadej as early as 1985. This project produced ethanol from cane. Later, both the public and private sectors realized the business potential of ethanol production and participated in its development and testing.

In Thailand, there are currently eight major producers who have government approval for the manufacture of ethanol. One of them is an ABB customer, Thai Agro Energy Co., Ltd. The plant, located in Dan Chang, Suphan Buri Province, is designed to produce 150,000 liters of ethanol from molasses every day. The ethanol has a purity of 99.5 percent and is sold to make a blend consisting of 10 percent ethanol with premium petrol. The blend is called gasohol, and is positioned as an alternative fuel for automobiles.

Based on the success of its products with the Thai Agro Energy, ABB won another project to deliver similar equipment to Petro Green (also in Thailand).

When Thai Agro Energy started the project in 2004, ABB was asked by the French licensor and contractor, Maguin, to put forward proposals for the control and electrical systems. Following many rounds of presentation, discussions and evaluations with the customer, ABB was selected to supply the motor control center (MCC) for the 380 V motor, the automation system for controlling the ethanol production process, and field supervision and commissioning services. The products and services ABB provided included conceptual design, detail engineering, application software programming, MCC and control panel design and manufacture, FAT[1)], SAT[2)] and overall commissioning. The plant started producing ethanol in the first quarter of 2005.

The automation system consists of two ABB Process Portal operator consoles, an AC800M controller unit and an S800 for 450 I/O signals. The latest automation technology from ABB, Industrial^{IT} 800xA system, is a fully integrated system designed to improve plant productivity. By gathering all the key process data from field instruments, Process Portal will supply customized displays including alarm lists, process graphics, control faceplates and trend displays. The operators are at ease to perform their control functions efficiently while working in the familiar Window XP environment. For example, the operators can start or stop a motor through Process Portal and the feedback signal will indicate the motor status. Several control faceplates can be displayed at the same time. Operators can identify root causes of alarms: Trend displays are important tools to help them to analyze the process status. These tools are helpful for in-depth investigation and trouble-shooting using run-time data or historical data. Scheduled and on-demand reports are readily produced in Excel and can be distributed to management.

In addition to customized displays, other information such as drawings and diagrams are available. This comprehensive operational environment reduces the time between decision and action. With real time information available, the maintenance team can reduce maintenance costs through early detection of performance problems with the equipment such as field instruments, motors, or the control system itself.

Based on the success of its products with the Thai Agro Energy, ABB won another project to deliver similar equipment to Petro Green (also in Thailand). Again, ethanol is produced from molasses in a very similar process delivered by Maguin from France. This plant was successfully commissioned in November 2006.

With ABB's Industrial^{IT} 800xA and Motor Control Center, Thai Agro Energy Co. and Petro Green (among others) are now well equipped to proceed with an efficient mass production of ethanol. This will benefit Thailand economically by reducing oil imports and ecologically by supplying alternative energy for a clean environment. All in line with the wish by His Majesty the King to make Thailand better for it's citizens!

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Footnotes

1) FAT: factory acceptance test
2) SAT: site acceptance test

Green oil from ethanol by-products

Little Sioux Corn Processors, a corn ethanol processing plant in Marcus, Iowa (USA), is benefiting from adding an oil extraction unit to its process. This system extracts corn oil from the by-products of ethanol refining. These products are typically used in low priced animal feeds. Little Sioux can now sell this oil as higher grade animal feed or biofuel. The extraction cuts wastage of raw material and improves profitability.

GS–Cleantech Corporation manufactures the add-on extraction system, called Corn Oil Extraction System, or COES. COES is a completely automated system that integrates easily into an existing ethanol plant with no process interruption. COES utilizes a full complement of ABB products, including the Compact 800 HMI, a full PC-based control system with 800 series controllers and PLC units, ACS 800 Variable Frequency Drives, low voltage products and instrumentation (pressure transmitters).

The ethanol processing by-product – dry distiller's grain – is valued at 3.5 to 5 cents/lb. The oil currenty extracted from this by-product is worth 30 to 36 cents/lb after conversion to biodiesel.

The control system used in COES, a Compact Products 800, is an open control system based on standards that ensure it can be combined with other products on the automation market.

The integrated ABB system has helped Little Sioux reclaim corn oil that would otherwise have been wasted.

The ABB MS Manual Motor Protectors combined with the A-Line contactors used in this solution provide a compact and reliable method for switching and protecting motors against failures. Operators benefit from reduced downtime costs when utilizing these products in combination.

Unrivalled in its scope and applications expertise, ABB provides a wide variety of FOUNDATION Fieldbus, PROFIBUS and HART enabled instrumentation solutions certified to international standards.

At Little Sioux, an ABB 800xA Compact 800 workstation in the control room is connected to two non-redundant AC800M processors in the field. Two remote ABB Process Panels in the field provide the flexibility to control processes from either the control room or the field. The ABB system controls evaporators and the extraction system.

The extraction system consists of a specially designed pre-treat system, oil separation equipment and a storage system. The product is routed from the evaporators to the pre-treat system, then to a high-speed centrifuge which separates the oil from the by-products. The oil is then pumped into custom designed storage tanks for further purification. Remote ABB PLC's control the entire system and ensure a pure corn oil is ready to be pumped into semi-trailers.

GS-Cleantech is a technology developer that provides engineering and commercialization of technologies which improve the environment as well as the profitability of their customers. It is a part of the Greenshift Corporation portfolio of companies, which all focus on developing technologies that help companies utilize natural resources more effectively.

The Little Sioux installation is one of three installed COES systems. Several others are under construction. Improving the economics of ethanol production is a key objective in creating new ideas to process waste into useful products making this process more viable in the long term.

The objective for Little Sioux is to extract more fuel and more value from each bushel of corn it processes. The integrated ABB system has helped Little Sioux reclaim corn oil that would otherwise have been wasted. This product is now not only viable, but a desired commodity. The working relationship of GS Cleantech and ABB benefits their customers, but arguably the biggest benefactor of all is the environment.

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Biomass gasification and fuel synthesis

Biomass-derived fuels, chemical compounds, and power from renewable sources such as forests and farm land are foreseen to become important energy sources for a sustainable future. Advanced biomass conversion technology will play a crucial role in at least reducing, if not eliminating, oil dependence in some countries such as Sweden. At the same time it will mitigate the negative effects of greenhouse gas emission generated from the combustion of fossil fuels.

In late 2004, an EU sponsored research project for Clean Hydrogen Rich Synthesis Gas (CHRISGAS), based on biomass started in the town of Värnamo located in the forested area of southern Sweden. An existing research pilot plant built in the 1990ies by Sydkraft AB, a Swedish utility company, and later mothballed, will be retrofitted to enable thermo-chemical derived vehicle fuel research under the auspices of Växjö University. The formation of a non-profit company, the Växjö Värnamo Gasification Center, VVBGC, in 2003 to operate and maintain the plant initiated investments in the rebuild of the existing process for its new purposes. With EU's Framework 6[1] and the Swedish Energy Agency as key sponsors, the CHRISGAS project commenced on September 1, 2004 as a national and European venture in research and training.

Main objectives

The objectives of the CHRISGAS research project are to develop and optimize a process for the production of hydrogen-rich gas from biomass in an energy and cost efficient manner. This gas can then be upgraded to commercial quality hydrogen or to synthesis gas for further refinement into liquid fuels such as DME, (dimethyl ether), methanol or Fischer Tropsch diesel.

The primary focus is to demonstrate by 2009 the economic production of an intermediate product for the manufacturing of vehicle fuel from renewable feedstock – a clean and hydrogen-rich gas based on steam/oxygen blown gasification of biomass. This process step is followed by hot gas cleaning to remove particulates and steam reforming of tar and light hydrocarbons to further enhance the hydrogen yield. Two quantitative goals have been established. The gas generation capacity should reach 3500 Nm³/hour[2] with an accumulated operating time of 2000 hours.

> The objectives of the CHRISGAS research project are to develop and optimize a process for the production of hydrogen-rich gas from biomass in an energy and cost efficient manner.

The process

The process steps are shown in 1. The heart of the process is a low-pressurized steam/oxygen blown gasifier cyclone 1c typically operating at 10–15 bar pressure and 950 to 1000 °C. To reduce the inert gas consumption of the fuel feeder, a piston based system is being developed with a performance that exceeds the current one by two orders of magnitude. The biomass fuel is fed at a maximum rate of 4 ton/hour and consists of roots and branches. Gas cooling takes place downstream of the gasifier 1d. The optimal temperature in this phase is a research topic in itself and will be determined during testing. The steam

Footnote

[1] The EU's Framework Programme for Research and Technological Development is a major tool to support the creation of the European Research Area. FP_6 is the sixth such programme.

[2] A Nm^3 is a cubic meter of gas at normal, ie, atmospheric pressure conditions.

reformer 1g, catalytic or thermal, follows and provides for the first stage of chemical upgrading converting hydrocarbons (mainly methane) and tars to hydrogen and carbon monoxide. The determination of the optimal balance between these two components to achieve high yield of synthesis gas is one of the crucial research tasks. To further enrich the hydrogen in the raw gas and provide for additional upgrading, a water-gas-shift and a hydrogenation reactor 1j is placed after the cooling. The optimal temperature for this stage will be identified as part of the research program.

Topics that the technical challenges are related to are the scaling of the process from laboratory size to semi-full scale, making critical filters work at high temperatures and identifying the operating points that provide maximum yield. But more than all this, the greatest question requiring an answer is: "Can biomass replace natural gas in producing a synthesis gas of the quality required for further processing into biodiesel at a cost compatible with commercialization?"

To allow necessary process changes, research tests and quick modifications, the new equipment must have a degree of built-in flexibility. This requirement led the plant manager, Ola Augustsson, to select a new control system to help him achieve freedom to change and reprogram the system when necessary.

The ultimate goal is to transform the synthesis gas into vehicle fuel at cost effective prices.

Control system from ABB

After an evaluation process, ABB's system Freelance 800F was selected – including the operator interface DigiVis. Communication with existing sensors and actuators as well as with existing cross coupling had to be prepared. As a safety feature, a process shutdown system was included in case anything should go wrong in an experiment. The installation and commissioning took place during the summer of 2006. "ABB performed this work very well", says Ola Augustsson. "It was not so easy because of the restrictions the old equipment caused. Now we have an operator-friendly and flexible system for our research plans." The plant was tested late 2006 with excellent result. Further testing will continue in 2007.

Vision

The ultimate goal is to transform the synthesis gas into vehicle fuel at cost effective prices. This process step will not be implemented for another couple of years. It is however a well understood and mastered process and no major research is required as long as the feedstock (the synthesis gas) is of high quality and high yield. However, when the old Värnamo factory starts commercially producing real diesel from roots and pine branches, the reduced effect on the climate is the real winner.

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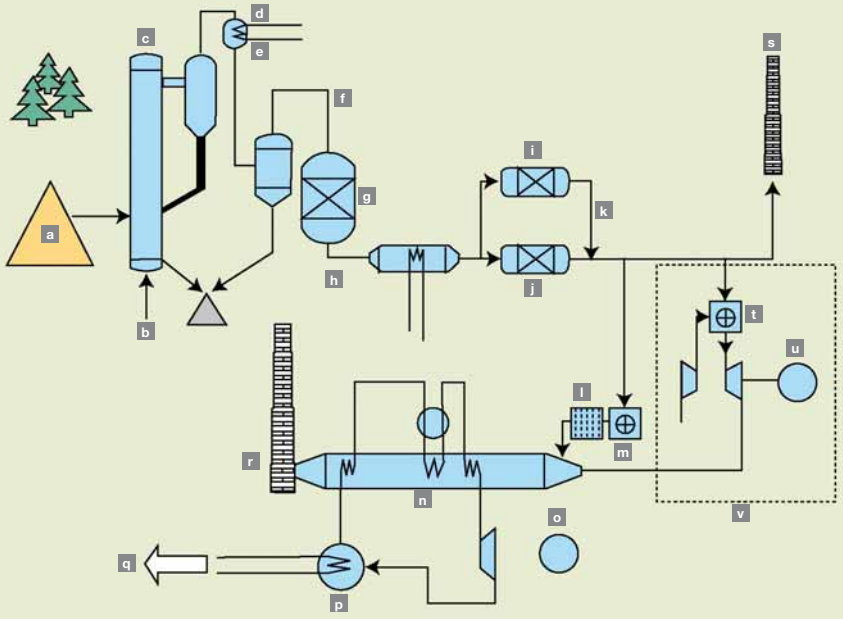
1 Ethanol production principles

Ethanol is an alcohol produced from a crop fermentation that converts starch into sugar (molasses) and again changes molasses into alcohol. Through distillation, a pure alcohol of 95 percent is obtained.



a Biofuel
b Steam + oxygen
c Gasifier
d Gas cooler
e Hot gas filter
f Steam + oxygen
g Reformer
h Gas cooler
i Water gas shift
j Hydrogeneration
k Synthesis gas
l Quench duct
m Burner
n Heat recovery boiler
o Steam turbine
p Condenser
q Cooling to air
r Stack
s Flare
t Burner
u Gas turbine
v By-passed processes

Fuel additives go green

Eleven years after building a sugar factory in Zeitz, Saxony-Anhalt, Germany, Südzucker AG set another milestone by building a bioethanol plant in the region during 2006. The main ingredient used to make bioethanol at the plant is wheat, but Südzucker can also make use of the by-products that result from its sugar operation, along with other kinds of grain that exist in abundance around Zeitz. The new plant can produce 260,000 cubic meters of bioethanol per year. This takes about 700,000 tons of grain and requires a cultivated area of about 100,000 hectares.

Bioethanol is a readily available, clean fuel used as a fuel additive in making environmentally friendly gasoline for combustion engines. It can be made from grain, corn, some tubers, sugar beet, sugar cane or cellulose plant material such as grass or wood based products. Bioethanol is basically alcohol, resulting from a process of fermentation, distillation/rectification and dehydration.

Today's effective gasoline standard allows for up to five percent added bioethanol. On Feb 15, 2007 the EU proposed that this should be raised to 10 percent by 2020.

The European Union is promoting the use of biofuels and other renewable fuels to help meet the EU's climate change commitments.

The standard also permits as much as 15 percent ethyl-tertiary-butyl-ether (ETBE) – an octane improvement that can be made from ethanol. Both substances are excellent gasoline additives and have superb environmental properties.

The European Union is promoting the use of biofuels and other renewable fuels to help meet the EU's climate change commitments, and to create environmentally friendly, secure supplies of fuel from renewable energy sources.

Managed by its Leipzig office, ABB has been part of the Südzucker project since late March 2004. This is also ABB's first major Profibus-PA installation: There are about 1,000 Profibus devices at Südzucker. In Zeitz, ABB automation experts used the new visualization screen and Industrial^{IT} 800xA Operator interface to connect to AC 800F controllers.

ABB has supplied cutting-edge process technology for the plant. The very short duration of the project presented a considerable challenge. Through close cooperation between all participating ABB partners, however, this challenge was turned into a success. The plant was commissioned in late 2006 and has been fully operational since early 2007 -contributing to a cleaner world.

Staff Report
ABB Review

Factbox The ABB contribution

For this project ABB supplied:

- The plant's process control system, consisting of 14 AC 800F controllers, seven operator control and observation units and two engineering stations. Its framework comprises about 16,000 I/O (input/outputs), most of which are decentrally equipped with S800 modules in more than 100 remote I/O housings
- A Motor Control Center (MCC) drives the entire building installation, including the layout for external and internal lighting
- The fire alarm system and the infrastructure for the IT data network
- Complete engineering, assembly, configuration and commissioning of all facilities

1 Südzucker's new bioethanol plant can produce 260,000 cubic meters (260,000,000 litres) of the clean fuel additive per year.