

PROCESS
technology

Bioethanol

bioprocess plants

VOGELBUSCH BIOETHANOL PLANTS

DRINK THE BEST AND DRIVE THE REST

Vogelbusch is a major global player in the engineering and construction of alcohol plants, and has introduced many ground-breaking improvements in alcohol process technology and design since its formation in 1921. Vogelbusch helped pioneer the fuel alcohol industry in Brazil and the USA in the 1970s, and it has since become an established process supplier in Asia and Europe as well.

The Austrian company has a long history of setting new standards for alcohol technology. A proud record of innovation includes the Vogelbusch Multicont® continuous fermentation process, and the integration of distillation, evaporation, molecular sieve dehydration and DDGS drying. These environmentally friendly, cutting-edge technologies contribute to the outstanding performance of Vogelbusch bioethanol plants.

Vogelbusch is the world's leading supplier of technology to the alcohol industry, with a current installed base of 5 million tons/year of bioethanol capacity.

WHAT MAKES VOGELBUSCH PROCESSES UNIQUE?

Vogelbusch focuses on developing reliable, efficient and environmentally sound processes. We aim for maximum plant availability, and as a result our plants regularly exceed their nameplate capacities.

Our engineering philosophy is based on a constant willingness to make innovations and an absolute commitment to meeting clients' requirements. Our modern in-house laboratory facilities and pilot plants, and synergies with other bioprocesses at our disposal open the way for highly specialized solutions. Our technology is not just advanced, but tried and tested, too.

We have extensive experience of a wide range of feedstocks, and state-of-the-art proprietary technology for every stage of the alcohol production process. World-famous developments pioneered by Vogelbusch include:

- | Vogelbusch MULTICONT® continuous fermentation process
- | Vogelbusch multi-pressure column system
- | Vogelbusch evaporation systems

Continuous development and improvement of our expertise ensures that all our technologies are truly state-of-the-art and not just off-the-shelf designs. All the latest advances are offered to existing and prospective clients. We select process equipment to provide an operator-friendly environment for increased productivity. And we strive for maximum long-term returns on your investment, and avoid short cuts and cheap designs that will ultimately reduce profitability.

Vogelbusch offers highly specialized custom solutions that optimize process economics for:

- | Use of multiple feedstocks
- | Combined or alternative production of bioethanol and neutral alcohol
- | Compliance with precise specifications for product quality, steam pressure, etc.
- | Local maintenance and construction conditions

IMPACTS ON PRODUCTION COST

The most important cost factors in bioethanol production are raw materials, energy and initial capital costs. Our advanced process design concepts for bioethanol plants have a significant impact on these cost drivers and on plant availability. Key issues in this regard are:

Continuous fermentation process

- | Low investment and operating costs
- | Outstanding yields, concentration and productivity
- | Reliable and stable operation for extended periods
- | Easy operation thanks to full automation

Low thermal energy consumption

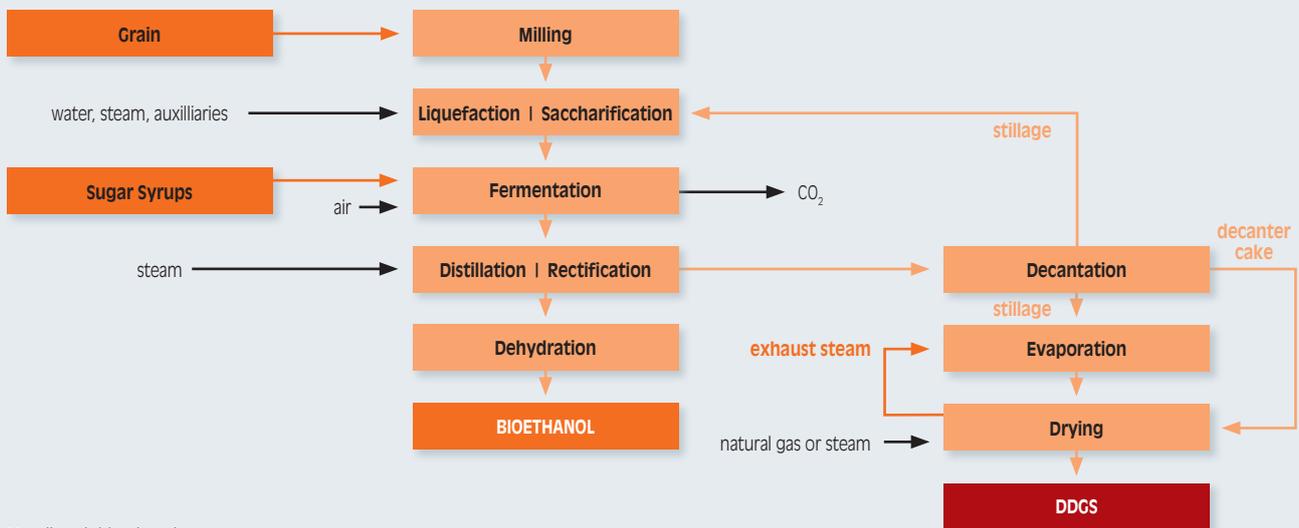
- | Recovery and reuse of secondary energy from process streams
- | Heat integration at each process stage and across the plant as a whole

Water saving and wastewater avoidance

- | Stillage recirculation
- | Residue water recirculation and reuse of vapor condensate
- | Re-use of treated wastewater in utilities (e. g. cooling towers) or for process needs

Because our technology brings top plant performance in terms of product quality, process economics and environmental impacts it also optimizes the long-term plant cost-benefit ratio. And the fact that it is proven removes a major obstacle to mobilizing project finance.





Vogelbusch bioethanol process

THE VOGELBUSCH BIOETHANOL PROCESS

Vogelbusch offers proprietary technology for every stage of bioethanol production. Fermentation and subsequent purification by distillation, rectification and dehydration are the core process groups. Raw material preparation, auxiliaries and by-product treatment are adjusted to the desired feedstock.

Flexible design concepts and technology can be precisely adapted to specified substrates, capacity, available steam pressure and energy costs. Each stage of the Vogelbusch bioethanol process is designed for full compatibility with clients' existing processes.

FEEDSTOCKS

Our key success factors include knowledge of, and field experience with input materials, and the ability to analyze their implications for bioprocesses precisely. Our equipment can process alcohol from a wide range of starch or sugar-containing substrates. These include wheat, corn, milo (grain sorghum), barley, rye, potatoes, cassava, sweet potatoes and wet milling by-products, as well as sweet sorghum, sugar cane and sugar beet in the form of molasses, thick juice or syrups. Yet another source are substrates from cellulose conversion processes.

The choice is a matter of plant location. For example, sugar cane is used in tropical zones, wheat is favored in Europe and maize is typical for North America.

RAW MATERIAL PREPARATION

Starch

Grains and tubers are milled before they are used in the process. Starch or by-products from wet milling plants do not require any special treatment and are fed directly to the liquefaction stage. In the liquefaction (conversion) step, starch is liquefied by enzymes at the right temperature, pressure and pH conditions. Each parameter is optimized for the type of raw material used. At the saccharification stage, the liquefied substrate is partly transformed into glucose. The saccharified substance is cooled down and fed directly to the fermentation unit. Final conversion of the starch into glucose takes place simultaneously during fermentation. The Vogelbusch Hotmash® process re-uses heat from hot stillage, resulting in significant steam savings.

DESIGN OPTION

Dry | Wet Milling Process

In the dry milling process the feed contains all the fibers, husks, etc. of the grain. The process is robust and simple, and provides good DDGS as a co-product. The wet milling process uses clear substrate (no fibers or sludge). The yield is higher but no DDGS is obtained.

Sugar

Molasses and sugar syrups seldom require special treatment, and are normally conducted straight to the fermentation unit. Where the substrate contains large amounts of inhibiting substances which would affect the fermentation pasteurisation and/or stripping may be necessary. Occasionally, a sludge removal process may also be required.

FERMENTATION

At the fermentation stage yeast transforms monosaccharides into alcohol. The Vogelbusch MULTICONT® continuous fermentation process consists of a prefermenter, and between four and seven main fermenters in series. Process conditions in the prefermenter are adjusted to promote yeast growth by adding nutrients and air, while in the main fermentation tanks the alcohol increases in concentration as mash flows through the system. A constant flow of substrate enters the fermentation unit and the same volume of liquid leaves the system simultaneously. Conventional batch fermentation systems can be employed for particularly challenging raw materials. With some substrates, yeast recycling can be used to improve yield and accelerate fermentation. Vogelbusch has designed plants that employ yeast recycling for non-fibrous raw materials such as molasses or starch milk.

DESIGN OPTION

Batch | Continuous Fermentation

Fermentation units can be implemented as batch, fed batch or continuous processes. Continuous systems are generally cheaper and easier to operate. Batch systems are sometimes preferred for highly inhibiting substrates.

DISTILLATION | RECTIFICATION | DEHYDRATION

The alcoholic mash is fed to the distillation column where the crude alcohol is stripped from the mash, leaving behind an alcohol-free liquid, the stillage. The crude alcohol is purified and concentrated up to about 94% vol.

A dehydration process is used to obtain anhydrous ethanol. Standard Vogelbusch technology employs a pressure swing adsorption (PSA) process using molecular sieves. The final water content can be reduced below 0.05% wt.

The Vogelbusch multi-pressure column system operates at different pressure levels in order to save live steam. Thanks to advanced thermal integration techniques, the energy consumption of the distillation | rectification | dehydration unit is reduced to figures as low as 1150 kg steam per 1000 liter bioethanol

BY-PRODUCT UTILISATION

Grain processing plants

In grain plants insoluble substances (fibers) in the stillage are removed by a decanter. Part of the decanted stillage is recycled to the liquefaction | saccharification unit which re-uses the latent heat and reduces the overall water demand of the plant. The other part of the stillage is pre-concentrated by the distillation unit reboilers, so as to reduce steam demand at the evaporation stage where it is concentrated. Solids leaving the decanters are mixed with concentrated stillage from the evaporation section and dried. The dried product is sold as powdered or pelletized distillers' dried grains with solubles (DDGS). Stillage is also a potential on-site biomass or biogas power source.

Sugar processing plants

Stillage from beet or cane molasses is directly fed to the evaporation section where it is concentrated in a range of 30–60% ds depending on the application. The concentrated molasses stillage (vinasses) can be sold as animal food additive or fertilizer, or can also be used as a fuel for process steam generation. No concentration is required for biogas production.

AVERAGE CONSUMPTION FIGURES

The table below shows the average consumption figures for the production of 1000 l bioethanol.

The figures are typical, and consumption may vary according to plant conditions.

DESIGN OPTION

Evaporation

Vogelbusch offers a wide range of proprietary evaporators including falling film, natural and forced circulation, and expansion designs. There is a choice of single or multiple effect evaporators, with or without thermal or mechanical vapor recompression.

DESIGN OPTION

Gas | Steam dryer

Decisions on dryer technologies are a matter of energy availability and cost. Where cheap steam is available indirect steam heated tube bundle dryers are used. Otherwise gas or light fuel oil fired dryers are employed. Both ring and rotary drum dryers are suitable.

PRODUCT QUALITY

Vogelbusch column systems are optimized for the product grades to be produced. They can be designed to comply with fuel ethanol standards such as ASTM D4806 (USA) or EN 15376 (EU), or individual consumer specifications.

DDGS – A HIGH-VALUE FEED CO-PRODUCT

While ethanol production consumes the starch in the grain, the protein, minerals, fat and fiber are concentrated during the production process. The dried product – known as distillers' dried grains with solubles (DDGS) – is a valuable animal feed ingredient. Some 30% of the raw material input can be recycled to the food chain and provide a substitute for protein (soya) production.

Additionally minor amounts of chemicals are necessary, the consumption is dependent on the raw material quality. The amount of enzymes required in starch conversion depends on the producer.

RAW MATERIAL			UTILITIES							
		Quantity kg	Steam kg	Power kWh		Cooling water ³⁾ m ³		Process water ⁴⁾ m ³		
			DDGS drying or vinasses concentration							
			no	yes ²⁾	no	yes	no	yes		
Wheat	STARCH	58%	2630	1650	4100	125	275	95	175	2.7
Corn		65%	2350	1550	3350	120	240	90	165	2
Cassava chips		65%	2350	1600	-	140	-	90	-	4
Beet molasses	SUGAR ¹⁾	50%	3240	1450	2550	70	100	100	160	7
Cane molasses		50%	3270	1500	2650	70	100	110	170	7.7
Cane juice; Sweet sorghum		15%	10700	1300	2650	70	100	100	170	1

¹⁾ fermentable sugar as disaccharide

²⁾ natural gas can also be used as heat source for DDGS drying

³⁾ (dT = 10K)

⁴⁾ partly replaceable by treated condensates

ENERGY SAVING FEATURES

Utmost energy efficiency is crucial to the profitability of bioethanol production. Vogelbusch designs include energy saving features at all process stages. Energy consumption at the raw material preparation stage is significantly reduced by recycling stillage, hot condensates and lees. Further savings are achieved by the use of expansion vapors.

An innovation introduced by Vogelbusch to the alcohol industry is the integration of distillation, evaporation and molecular sieve dehydration. This design minimizes energy requirements but does not overly complicate operations.

Vogelbusch introduced the multi-pressure system to the industry many years ago. With three sets of columns working at different pressure levels (vacuum, atmospheric and over pressure), every kg of steam entering the system is used three times. This and the fact that the molecular sieves for dehydration of alcohol are fed directly by the vapor from the top of the rectification column keeps steam consumption to an absolute minimum.

Our evaporation plants minimize energy consumption and operating costs and maximize available steam pressure. Multi-effect systems recycle the heat input up to nine times. Optional reduction of thermal energy demand is possible through mechanical vapor recompression. Further energy savings are achieved by the superior thermal integration with other process sections. For instance multiple effect evaporators driven by waste heat from the DDGS dryers can be installed at grain processing plants, resulting in zero life steam demand.

REDUCING GHG EMISSIONS

Reducing greenhouse gas (GHG) emissions is one of the main objectives of biofuel promotion policies. Energy efficiency is a proven, cost-effective way of cutting GHG emissions and contributing to sustainability. Driven by cost savings, energy-conscious design has long been a major focus for Vogelbusch. Primary energy use is reduced by recovering secondary energy and by thermal integration of processes.

Besides energy saving conversion processes, the careful selection of the primary energy source can cut GHG emissions. Use of biomass for combustion or biogas generation can open the way to energy self-sufficiency.



CONTINUOUS FERMENTATION

The Vogelbusch MULTICONT® continuous fermentation process was introduced back in 1970 with resounding success. The process has since been refined, and it is now considered the state-of-the-art technology for alcohol fermentation. The process is highly reliable, and will operate in a steady-state mode for extended periods of time.

The largest fermentation cascades consist of fermentation tanks with volumes of up to 5000 m³. Final alcohol concentrations of over 15 vol. per cent are regularly achieved and excellent yields are obtained. The process lends itself to full automation, and the capital cost is considerably lower than with older technologies. Today, three-quarters of the fuel ethanol produced in the USA is made using continuous fermentation.

OUR SERVICES FOR BIOETHANOL PLANTS

Vogelbusch provides bioprocess engineering, consultancy and contracting services, and licenses technology. Our process design packages for bioethanol plants include:

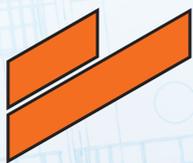
- | Pre-engineering
- | Basic process package:
 - Technology and process design | Supply of key equipment | Commissioning support and operator training
- | Detailed piping engineering
- | Turnkey supply of complete process units, e. g. distillation | rectification columns, stillage evaporators and dehydration

Highly skilled experts are available to upgrade or revamp existing facilities to:

- | Reduce utility consumption for low GHG emissions
- | Diversify feedstock
- | Increase capacity and yield
- | Improve product quality

For second generation pilot and demonstration plants Vogelbusch can integrate your hydrolysis process with proven first generation bioethanol technology.





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