

Bioethanol



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Process Technology

VOGELBUSCH BIOETHANOL PLANTS

Know-how and technology licensing

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 bioethanol process supplier around the world.

The Austrian company has a proud record of innovations that have become the state of the art, including the Vogelbusch MultiCont® continuous fermentation process, the MultiPressure column system and the benchmark-setting integration of all downstream units for cost-effective energy savings. These environmentally friendly, cutting-edge technologies contribute to the outstanding performance of Vogelbusch bioethanol plants.

WHAT MAKES VOGELBUSCH PROCESSES UNIQUE?

Vogelbusch focuses on developing reliable, efficient and environmentally sound processes, with an absolute commitment to meeting clients' requirements.

We have **extensive experience** of a wide range of feedstocks, and proprietary technology for every stage of the alcohol production process. 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.

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.

Vogelbusch offers custom-designed solutions that **optimize process economics** for:

- | Use of multiple feedstocks
- | Combined or alternative production of bioethanol and neutral alcohol
- | Compliance with precise client specifications for product quality, steam pressure, etc.
- | Local maintenance and construction conditions
- | Maximum plant availability in an operator-friendly environment

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 and vessel engineering, process automation
- | Turnkey supply of single process units, e. g. distillation | rectification, stillage evaporation and dehydration

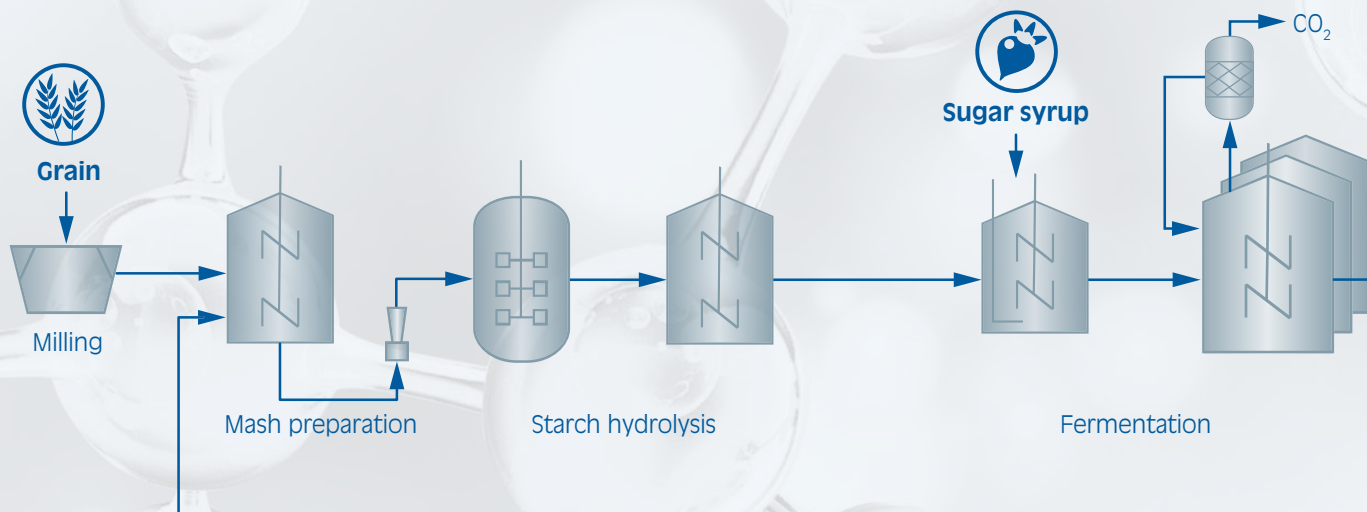
Highly skilled experts are available to upgrade or revamp existing facilities to:

- | Reduce utility consumption to avoid emissions
- | Diversify feedstock
- | Increase capacity and yield
- | Improve product quality

For second generation plants Vogelbusch can integrate client's hydrolysis process with proven first generation bioethanol technology.



THE VOGELBUSCH BIOETHANOL PROCESS



Vogelbusch offers proprietary technology for every process step. Along with the design of complete plants, we also supply single processing units and integrate them into existing manufacturing facilities. Our flexible design concepts and technology are precisely adapted to specified substrates, capacity, available steam pressure and energy costs.

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 ethanol technology can utilize 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 climate: mostly sugar cane is used in tropical zones, sugar beet and wheat is favored in Europe and maize is typical for China and North America.

RAW MATERIAL PREPARATION

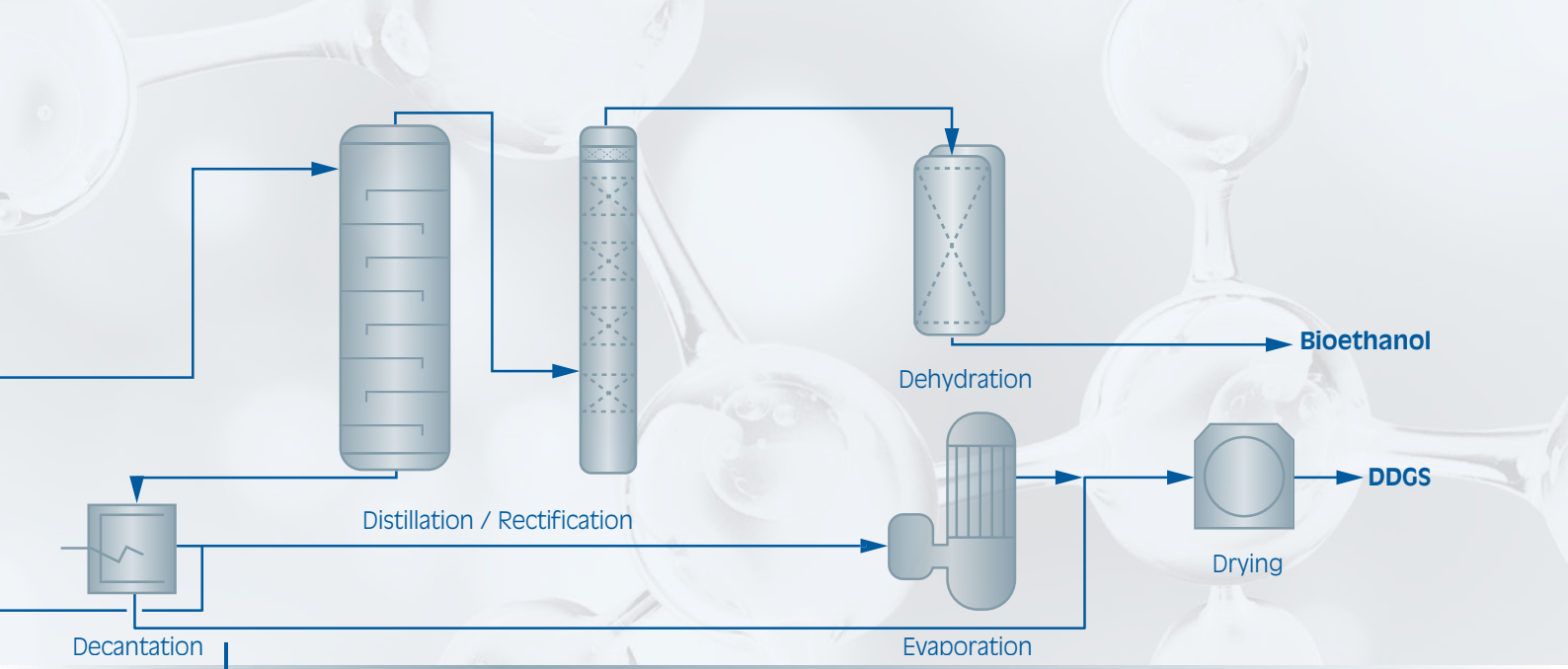
Starch

Grains and tubers are milled before they are used in the process; starch or by-products from wet milling plants can be fed directly to hydrolysis. In a first step, enzymes liquefy the starch at certain temperature, pressure and pH conditions. These parameters vary depending on the type of raw material used. At the saccharification stage, the liquefied substrate transforms into glucose. When partially saccharified, the mash is cooled down and fed directly to the fermentation unit. Final conversion of the starch into glucose takes place simultaneously during fermentation. To re-use water and latent heat, the Vogelbusch HotMash® process recycles a stillage stream from decantation.

DESIGN OPTION

Dry | Wet Milling Process

In a dry milling process the feed still 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 without fibers or sludge; the alcohol yield is higher but less animal fodder is gained.



Sugar

Molasses and sugar syrups seldom require special treatment; they are diluted, acidified and fed straight to the fermentation unit. Pasteurization and/or stripping may be necessary if a substrate contains large amounts of inhibiting substances that would affect the fermentation. Occasionally, a sludge removal process may also be required.

FERMENTATION

At the fermentation stage, yeast is employed to convert monosaccharides into alcohol. In the continuous Vogelbusch MultiCont® fermentation process, a constant flow of substrate enters the unit and the same volume of liquid leaves the system simultaneously. Fermentation starts in a pre-fermenter under adjusted conditions that promote yeast growth. The fermenting mash flows steadily through a series of main fermenters, while the alcohol concentration increases.

Final alcohol concentrations in the mash of 13 - 16% vol (depending on raw material) are regularly achieved. From the last fermenter the alcohol mash is fed to an intermediate tank for distillation.

The heat generated during fermentation is removed via external heat exchangers, exhaust air from the fermenters is led through a scrubber for recuperation of alcohol from the carbon dioxide stream. With some non-fibrous substrates such as molasses or starch milk, yeast recycling can be used to improve yield and accelerate fermentation.

Conventional batch fermentation systems may be employed for particularly challenging raw materials.

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 in use for the ease of processing highly inhibiting substrates (such as low-grade molasses), if higher alcohol concentrations are necessary or when feedstock types are to be switched frequently

Bioethanol

DISTILLATION | RECTIFICATION | DEHYDRATION

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

The Vogelbusch MultiPressure system operates three sets of columns at different pressure levels. The finely balanced application of vacuum, atmospheric and overpressure allows re-using the heat input multiple times for a significant reduction in live steam consumption.

A dehydration process is applied to obtain anhydrous ethanol. Standard Vogelbusch technology employs a pressure swing adsorption (PSA) process using molecular sieves that allow for a final water content below 0.05% wt.

Thanks to advanced thermal integration techniques, the energy consumption in D/R/D is reduced to figures as low as 800 kg steam per 1000 liter bioethanol.

PRODUCT QUALITIES

Vogelbusch offers highly specialized solutions that optimize the system for compliance with precise product specifications. They can be designed for fuel ethanol standards such as ASTM D4806 (USA), EN 15376 (EU), ANP 19/2015 (Brazil), GB 1850-2013 (China), as well as individual consumer specifications.

DESIGN OPTION

Coproduction of extra neutral alcohol

For a flexible product portfolio, an **annex distillation** for neutral alcohol can be integrated into the bioethanol facility with economic benefits (draws from neutral alcohol are utilized in bioethanol). An alternate solution is a **switch distillery**, which is designed for a flexible inline product switch for either bioethanol or neutral alcohol within one process line, without compromising the steam saving properties of the plant.



BY-PRODUCT UTILISATION

By-products make an important contribution to the economy of the plant.

Grain stillage

Proteins, minerals, fat and fibers contained in grain stillage are a valued source for by-products. As an alternative, the stillage can be utilized as on-site power source (incineration, biogas). The insoluble substances in the stillage are removed by a decanter. Part of the decanted stillage is recycled to the mash preparation. Pre-concentration of the other part of the stillage in distillation unit reboilers reduces the steam demand in the next process step, the evaporation.

Corn oil separation

For the recovery of corn oil, tricanter separate concentrated stillage that is taken from and returned to evaporation.

DDGS line

Solids leaving the decanters are mixed with concentrated stillage from the evaporation and sent to the drier. The powdered or pelletized product is an animal feed ingredient known as DDGS (distillers' dried grains with solubles); optionally WDG or WDGS (wet distillers' grains with solubles) can be considered.

DESIGN OPTION

Gas / Steam dryer

Technology choice is driven by energy availability and costs. With cheap steam available, indirect heated tube bundle dryers are used. Otherwise gas or light fuel oil fired dryers are employed; both ring and rotary drum dryers are suitable. During procurement, we help our clients choose the best deal.

Sugar stillage

Stillage from beet or cane molasses is directly fed to the evaporation section where it is concentrated in a range of 30–65% ds (depending on the application). The concentrated molasses stillage (vinasses) can be sold as animal feed additive or fertilizer, or incinerated to generate process steam. No concentration of the stillage is required for biogas production.

DESIGN OPTION

Evaporation

We offer 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 (TVR / MVR). Each system is selected and customized in line with the specific concentration needs.



ENERGY SAVING DESIGNS

Utmost energy efficiency is crucial to the profitability of bioethanol production. The primary energy demand can be lowered considerably by recovering secondary energy and by thermal integration. Our innovative designs save energy throughout the ethanol plant:

Energy consumption in raw material preparation is reduced significantly by **recycling** stillage, hot condensates and lees, and by the use of expansion vapors.

Further savings are achieved by **heat integration** of distillation, evaporation and dehydration process, an innovation introduced to the industry by Vogelbusch.

Vogelbusch also pioneered the MultiPressure distillation system decades ago. With sets of columns working at different pressure levels, every kilogram of steam entering the system is used up to **three times**. This and feeding the dehydration directly with alcoholic vapor from the top of the rectification column keeps steam consumption to an absolute minimum.

Customized evaporation systems take available steam pressure and utilities into account, with multi-effect systems recycling the heat input up to **nine times**. Optional reduction of thermal energy demand is possible through mechanical vapor recompression.

Thermal integration of the evaporation with other process groups can further reduce the primary energy demand. For instance in grain processing plants, multiple effect evaporators driven by waste heat from the DDGS dryers result in **zero live steam** demand for evaporation.

Process optimization of this sort cuts operating costs and improves the environmental footprint of the plant.

REDUCING GHG EMISSIONS

Energy-conscious design is a proven, cost-effective way of cutting greenhouse gas (GHG) emissions, which is a core indicator of sustainability assessment programs. In addition, the careful selection of the primary energy source helps reduce GHG emissions. Vinasses incineration or biogas generation open the way to energy self-sufficiency of the plant.

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 re-use 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 ensures the long-term returns on your investment. In addition, the fact that it is proven removes a major obstacle to mobilizing project finance.

AVERAGE CONSUMPTION FIGURES

The table below shows the average consumption figures for a complete plant for the production of 1000 liter bioethanol. The figures are typical, and consumption may vary according to plant conditions.

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 enzyme producer.

RAW MATERIAL			UTILITIES				
		QUANTITY kg	STEAM kg		POWER kWh		
			DDGS drying or vinasses concentration				
			no	yes ²⁾	no	yes	
Wheat	STARCH	62%	2420	1400	3150	115	260
Corn		65%	2285	1250	2750	110	220
Cassava chips		65%	2320	1350	-	115	-
Molasses	SUGAR ¹⁾	50%	3210	1700	3000	65	105
Cane juice; Sweet sorghum		18%	8640	1200	2550	60	90

¹⁾ fermentable sugar as disaccharide

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



PYCNOMETER

A pycnometer, as shown above, is a measuring device for the density (specific weight) of solids or liquids. In addition, the composition of solutions (e.g. alcohol content in bioethanol) can be determined.



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We make biotechnology work