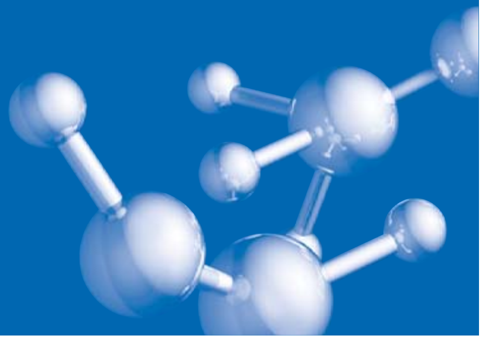
Lurgi

Bioethanol



As a result of new statutory regulations, bioethanol is increasingly gaining in importance as a gasoline additive. Lurgi's activities for the processing of renewable resources principally focus on biodiesel and bioethanol.

Bioethanol is predominantly produced by fermentation of sugar and starch containing materials, mainly cereals. A general layout of such a bioethanol plant is shown in figure 1. The process is subdivided into production of ethanol (fermentation, ethanol purification and downstream stillage processing.

Bioethanol Plant Block Diagram

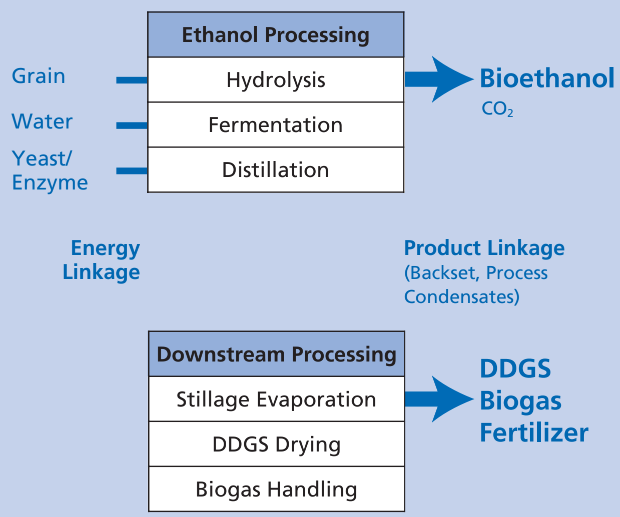


Figure 1

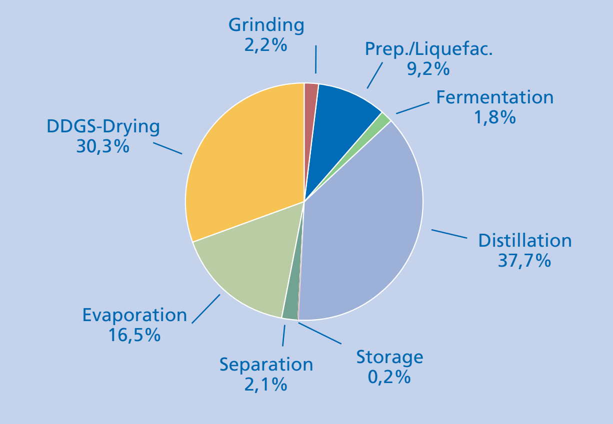


Abbildung 2: Energy Split and Distribution

The energy consumption of such plants is essentially influenced by the method of mash preparation, the ethanol distillation and rectification concept and the stillage processing including DDGS drying. Figure 2 shows the average energy consumption of the different process sections of a bioethanol plant.

When using cereals (corn, wheat, barley, rye) as raw material, the plants can be operated safely as a function of mash viscosity, at DS contents of between 25 and 35%. The kind of cereal used exerts a significant influence on the maximum realizable DS content. On average, about 1.5 to 2 tons of water per ton of grain processed have to be coped with, mostly by evaporation. The figures illustrate that a reasonable utilization of the process water, the multiple use of energy streams and the mash preparation stage at a high DS profile are decisive factors for the economics of the process. The use of secondary energy also calls for in-depth evaluation and analysis of the specific process conditions (e.g. of the allowable temperature profile) and energy sources available.

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As can be inferred from figure 2, the stillage evaporation and DDGS drying operations have high energy consumption. Especially in the drying process, extremely large amounts of water have to be evaporated as a result of the low degree of pre-dewatering (approx. 30 to 35% DS). From the aspect of energy economics it is necessary therefore to look for possibilities of utilizing the dryer vapors as a source of energy in the plant. The following issues have to be discussed:

- Where and how to use the dryer exhaust as an energy source in the plant?
- Are there any other methods of stillage processing or use?

An important aspect of using the dryer exhaust as energy source is its inert gas content (air, gases of combustion). In line with increasing inert gas content the condensation temperature of the water vapor is decreasing so that the usable temperature range is constrained (directly heated dryers). Moreover, the steam cannot be utilized for direct heating because many of the consumers are operated under vacuum and the high inert gas content would jeopardize the vacuum systems. Table 1 summarizes the results of studies of several plant concepts with different energy integration methods. According to Version 4, the total amount of vapors of an indirectly heated dryer is recycled to the plant. Compared to a conventional plant (Version 1, directly heated DDGS dryer), the consumption of heating steam can thus be reduced to about 45% of the base version.

Anlagen-variante	Dampfver-brauch (t/h)	Prozentualer Anteil (%)	Comment
Version 1	64	100	Base-Versions (Direct fired Dryer)
Version 2	58,6	91,5	Integration of Waste-steam from the Dehydration
Version 3	41,6	65	DDGS-Dryer as Energy supplier (Rotary Dryer)
Version 4	28,5	44,5	Total Integration of DDGS-Dryer (Closed System)

Table 1: Steam consumption in a bioethanol plant with different energy savings Feedstock: Grain (Rye) Capayitiy: 100000 t/year Bioethanol

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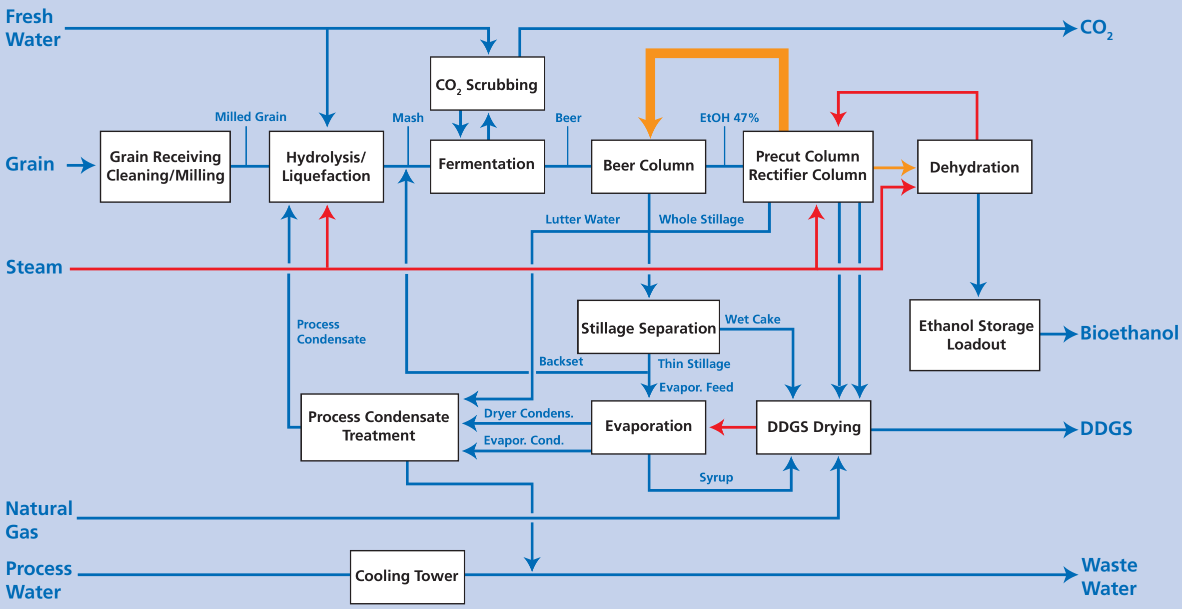
Bioethanol

Another possibility of stillage processing or use is to produce biogas. Biogas is obtained by anaerobic fermentation in tanks with methane bacteria under exclusion of air. In practice, approx. 450 to 550 m³n of gas can be generated per ton of DS in the substrate. Bio sludge and digestion water are the residues of this process. Figure 3 shows a combined bioethanol/biogas plant. The raw material is rye in this case, and the complete stillage is utilized for biogas production. The biogas product is cleaned and combusted to produce turbine steam. The turbine is coupled with a generator for electricity production.

Bioethanol/Biogas Plant



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The total steam consumption of the plant can be covered by the turbine exhaust steam. Digestion water and bio sludge are concentrated, dried and can be exported to be used as fertilizer. Table 2 summarizes the parameters of a plant for the production of 160,000 t/a bioethanol.

Products	Generation
Ethanol	20 t/hr
CO_2	20.5 t/h
Fusel Oil	0.3 t/h
Techn. Alcohol	1.1 t/h
Steam	max. 100 t/h (150/3bar)
Electricity	20 MW
Fertilizer	10.5 t/h
Feedstock/Utilities	**Consumption**
Grain	70 – 75 t/h
Process Water	45 t/hr
Fuel Gas	0.1 – 0.3 t/h
Waste Water	10.3 t/h
Steam	77 t/H (3 bar)
Electricity	7.8 MW
Chemicals	0.5 t/hr

Table 2: Key figures of an interlinked bioethanol/biogas plant (Capacity 200 Mio. liter ethanol per year)

The following features corroborate the benefits of this technology:

- Standard sizes with process modules for simultaneous ethanol and biogas generation or DDGS production
- Intensive waste energy utilization
- Indirectly heated DDGS dryer with low emission rates
- Multi-effect energy utilization in conjunction with the generation of biogas and electricity
- Efficient and proven hydrolysis and fermentation technology using thermostable yeast and high DS contents

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