Bioethanol Technology

GEA Process Engineering

GEA Wiegand

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Introducing GEA Wiegand

GEA Wiegand is a leading supplier of bioethanol process technology, providing the engineering, equipment and construction expertise for industrial scale plants. Our expertise covers the preparation and handling of raw materials to the dehydration of finished products and processing of the stillage and co-product streams. With an established track record and international reputation, GEA Wiegand is known for systems that optimise energy efficiencies and maximise production yields, plants that perform reliably and deliver products that are consistently of the highest quality.

The GEA Wiegand Company

GEA Wiegand employs some 230 engineers, technologists and supporting staff at our head office in Ettlingen, near Karlsruhe, Germany. Various engineering disciplines, research and development centre and manufacturing departments interact closely with each other to ensure that customers' expectations are met in terms of quality, performance and plant reliability.

As the process technology provider, GEA Wiegand undertakes the full performance and contractual responsibility where this is required, with single accountability providing security and confidence to both customers and investors alike.

In the GEA Group

GEA Wiegand is a part of the GEA Group AG, an international technology group that focuses on process engineering, equipment and plant engineering. Sales revenue in 2005 totalled € 4.5 billion, while the company employs some 17,500 people.

Through its subsidiaries, the GEA Group endeavours to hold the market and technology leaders in their respective fields, while the company is listed in the Frankfurt MDAX index.

Innovations

GEA Wiegand has an impressive 100-year history in the specialist field of thermal separation. A commitment to ongoing research and development ensures the continuation of our technological leadership. New products are tested, processes and equipment are developed and optimised. The results of these developments are reflected in the numerous patents held and in our ability to maintain our class leading position, with some 4,500 reference plants installed over the past 5 decades.

International Orientation

GEA Wiegand plants are to be found in many different areas of industry throughout the world. Systems are sold and supported through a global network of GEA Wiegand sales offices.

Quality

Our customers depend on the highest degree of precision and reliability. The GEA Wiegand organisation is certified according to the international standard DIN EN ISO 9001 and is authorized to build equipment in accordance with the German AD-Merkblatt HP0, the American Society of Mechanical Engineers (ASME U-STAMP) and in accordance with the latest European standards and pressure equipment directives to CE mark status.

Financing

The trend towards renewable biofuels is an extremely important subject due to the impact of climate change on the world around us. Financing schemes are therefore available that assist in the establishment of new energy efficient and renewable technologies. Revenue from trading *carbon credits* within the EU Emissions Trading Scheme supports the development of combined heat and power (CHP) plants built in conjunction with bioethanol plants, for example. Support for the development of business plans is a key area where GEA Wiegand provides assistance in the financing of large projects.

Research and Development

At our dedicated R&D Centre, state-of-the-art pilot plants and analytical equipment are available for investigations in the areas of bio-processing, fermentation, distillation, rectification, stripping, evaporation, membrane separation and ethanol dehydration.

GEA Wiegand R&D Centre

Tests in the fields of:

- Starch liquefaction and saccharification
- Fermentation
- Evaporation, distillation, rectification and stripping technologies
- Ethanol dehydration
- Membrane filtration MF, NF, UF and RO
- Complete process studies
- Recommendations

100 Years of Research and Development

Our R&D laboratory represents a significant investment demonstrating GEA Wiegand's market- and technological leading position. A complete fermentation pilot plant is available for the conversion of starch and sugar substrates into ethanol. State-of-the-art laboratory equipment is available for analytical purposes including gas chromatograph (GC) and high-performance liquid chromatograph (HPLC) machines. We investigate feedstocks, enzymes and yeasts, optimising yields and validating performance while providing the necessary data to undertake detailed equipment designs. For the thermal separation processes – distillation, rectification and stillage concentration – products are processed through pilot plants where a range of thermo-physical properties are measured, including boiling point elevations, heat transfer coefficients, viscosity, surface tension and solubility curves in order to determine optimum performance and concentration regimes.

From Acetone to Zeolite

Thermal and membrane separation technology represents a specialist area of expertise within our business for which numerous pilot- and lab-scale plants are available. To date, more than 3,000 products have been tested in our facilities, with an alphabetical list ranging from Acetone/Alcohol mixtures to Zeolite.

Manufacture

Manufacture, Installation and Dispatch

GEA Wiegand manufactures equipment in Beckum, where our employees are experts in the fabrication of vessels in stainless steels and materials such as titanium and nickel alloys (e.g. Hastelloy), Duplex and Super Duplex alloys. Columns of up to 4,600 mm diameter and 50 m in length are built in a factory covering 6,500 m^2 with a lifting capacity of 120 tonnes. Pressure vessels are constructed in accordance with the German AD-Merkblatt HP0, ASME, European CE mark standards and the Pressure Equipment Directive. Our engineers use up-to-date computer design tools, such as FE analysis, 2-D and 3-D draughting methods.

Specialist automated procedures, from the preparation and welding of joints, to the rolling and welding of tubes into tubesheets, provide high standards of quality and manufacturing efficiency.

Our quality control unit is responsible for ensuring that equipment complies with the design and required quality standards. Non-destructive test procedures are carried out using X-ray and ultra sound testing, spectral analysis, dye penetration, surface cracking and hardness testing.

GEA Wiegand – Milestones on the Road to Success

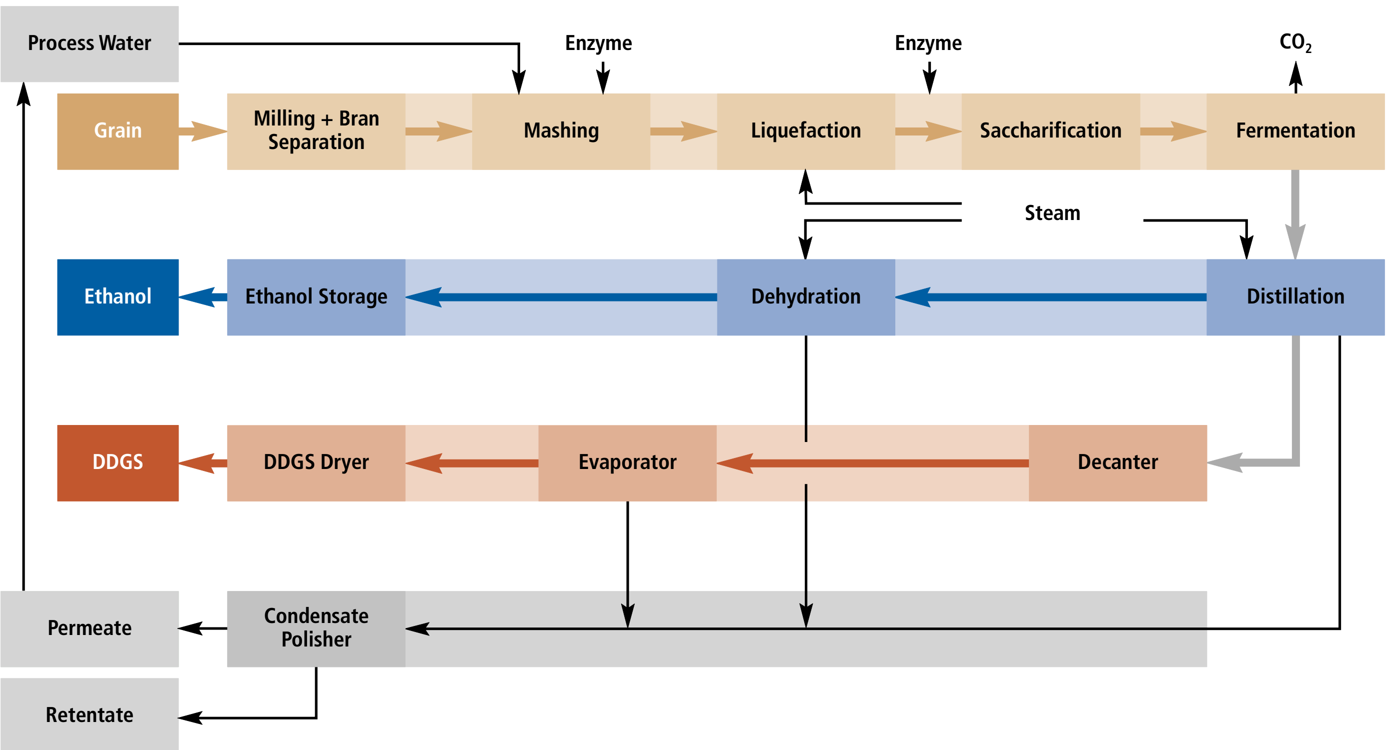
1908	Wilhelm Wiegand patents the multiple-effect circulation evaporator
1948	Wiegand Apparatebau GmbH re-established in Karlsruhe
1953	Introduction of the Wiegand falling film evaporator to the market
1957	Construction of Wiegand's own laboratory in Karlsruhe
1978	Tapioca bioethanol plant built in Brazil
1979	50th application for a patent in 54 countries since 1948
1984	Wiegand acquired by the GEA Group
1986	Wiegand acquires the manufacturing assets of distillation specialists, Gebrüder Becker, Beckum
1992	Delivery of a rectification and dehydration plant for 60,000 l/day alcohol
1996	Delivery of a complete turnkey processing line for 170,000 l/day beverage alcohol
2000	Delivery of the world’s largest falling film evaporator, handling potato starch waste water
2002	Establishment of GEA Filtration in Ettlingen
2004	Commissioning of Europe's most advanced bioethanol plant producing 330,000 l/day
2005	Installation of a new Fermentation pilot plant equipped with GC and HPLC analysers in our R&D centre

An Introduction to Bioethanol

Bioethanol is an environmentally friendly fuel for vehicles that normally run on petrol. As a renewable source of energy, it reduces demand on fossil fuels while it burns more cleanly and with reduced emissions of CO_2, a greenhouse gas.

As an energy source, bioethanol is carbon neutral in that it reduces, by up to 70 %, the amount of greenhouse gas released into the atmosphere. The CO_2 released during ethanol production and combustion in an engine has already been absorbed from the atmosphere during the growth of the crops due to photosynthesis.

The reduction of greenhouse gases, to meet the climate change targets set by the Kyoto Protocol, is responsible for fuelling the current boom in biofuels. The European Union set road fuel targets under its Biofuels Directive at 2 % for 2005, rising to 5.75 % in 2010 in order to meet its Kyoto obligations, with a view to introducing higher targets as the market was developed. Petrol blends containing up to 5 % ethanol are already available in parts of Europe and do not affect standard vehicle



manufacturer's warranties. *Flexible fuel vehicles* that use E85, a blend of 85 % ethanol and 15 % petrol, are in use in countries such as the USA and Sweden, while ethanol blends are used in Brazil and in parts of Canada, amongst others.

Bioethanol is produced by the fermentation of sugar, a well-established process used in the production of beer and alcohol. Carbohydrates such as starch from cereal and tuber crops – which is enzymatically converted into simple sugars – and natural sugars from sugar beet, sugar cane and sweet sorghum crops are fermented using yeast to produce a mash containing ethanol, water and unfermented solids. Distillation columns separate ethanol from the fermented mash, with additional purification taking place in rectification columns to produce an ethanol and water mixture. Dehydration is the step of removing the last of the water, taking the mixture beyond its azeotropic equilibrium to produce anhydrous ethanol, or bioethanol.

A significant advantage of bioethanol is that it can be blended with petrol as both an oxygenator and octane enhancer.

Environmental concerns due to the widespread use of MTBE (methyl tertiary butyl ether, a possible carcinogen) in unleaded petrol have prompted drives to seek alternatives. Bioethanol provides an ideal solution in that it is a renewable and environmentally friendly petrol extender, while providing a direct substitute for MTBE as an octane enhancer. Ethanol is also suitable as a feedstock for producing other octane enhancers such as ETBE (ethyl tertiary butyl ether) or TAEE (tertiary amyl ethyl ether), considered safer than MTBE.

Additional revenue streams are available from the spent products that result from ethanol production. These are usually dried to produce DDGS (distiller's dried grains with solubles) marketed as a protein and nutrient rich animal feed for cattle, pigs and poultry. Alternatively, the biomass can be utilised as a renewable fuel source, producing electrical power and heat for the process, or for conversion into methane for use as a fuel. These energy conversion technologies enhance the overall production energy balance and enable further *carbon credits* to be earned.

Milling and Product Preparation

Raw materials constitute a significant portion of the production costs, making it important to carefully design the process that will provide the greatest yield while minimising power consumption. GEA Wiegand works with proven providers of mill and starch preparation technologies, ensuring the most effective and reliable solutions are used.

In the case of cereal feedstocks, particle sizing and distribution has a significant influence on the process. The feed grain is therefore milled to a uniform size to accelerate processing time and improve yields. Milling too fine a flour unnecessarily increases power consumption, while the screening of larger particles to improve particle size uniformity improves the dextrin and ethanol conversion yields during the subsequent saccharification and fermentation steps.

Expertise in the field of starch processing enables valuable components to be extracted from the grain. This fractionation offers the benefits of yielding valuable co-products, which otherwise do not contribute to the ethanol conversion process, and enhanced performance. In the case of gluten – a temperature sensitive protein – the distillation plant can be designed to operate more effectively at higher temperatures, thereby reducing investment and energy costs. Furthermore, the removal of bran and fibres from grain reduces the non-fermentable mass flow through the distillation and drying train, meaning lower water and energy consumption. Where the spent co-products are finally dried for DDGS production, the dryer heat load and utility requirements are reduced if there is no need to dry the bran which has been separated prior to milling.

Wet milling as used in the starch industry allows the A- and B-starch fractions to be extracted in 3-phase separators. A-starch is converted in starch refineries to glucose and other sweeteners, while the B-starch fraction remains a suitable co-product for conversion to bioethanol. It is also possible to extract vegetable oils from the wheat or corn germ, which can be sold as a separate value-added product.

Optimum milling and product preparation strategies vary from product to product, while access to markets and prevailing conditions determine the extent to which alternative processing strategies can be realised. It is therefore important to fully consider the strategic variables when making these design decisions.

Liquefaction, Saccharification and Fermentation

Liquefaction and saccharification is the conversion of polysaccharide starch molecules into monosaccharide fermentable sugars. Liquefaction begins by mashing the starch containing flour into a liquid slurry using warm water. The mash is heated, typically by means of a steam jet cooker, where the combinations of heat and alpha-amylase enzymes gelatinise and thin the starch. Alpha-amylase breaks up the long starch molecule, a process known as hydrolysis, converting starch to maltodextrin, a simple sugar hydrolysate. The hydrolysed starch is converted further in the saccharification step, where the use of glucoamylase enzymes in a temperature and pH controlled environment completes the conversion of available dextrin into fermentable glucose.

A sanitary environment is provided by GEA Wiegand's design of the plant and process control system, with the aim of minimising bacteriological contamination and spoiling. Contamination results in the formation of lactic acid, which hinders the fermentation process and destroys the starch-to-ethanol conversion yield. With the use of antibiotics in products entering the food chain having been disallowed in Europe since 1998, bacteriological contamination is kept in check by means of a controlled sanitary design, cleaning in place procedures and by managing the fermentation rate and yeast nutrition. This permits the safe use of spent co-products in the animal feeds markets.

Advances in enzyme and yeast technologies enable new levels of performance in terms of viscosity reduction (e.g. xylanase and beta glucanase), conversion times, process temperatures and yields, allowing greater optimisation on equipment design and energy use. Commercially available enzyme packages permit liquefaction and starch hydrolysation using uncooked starch at low temperatures. GEA Wiegand's expertise allows flexible plant designs that permit switching between processing methods, reducing dependency when market conditions are unfavourable.

Fermentation

GEA Wiegand routinely provides fermentation plants with yeast propagating systems for the fermenters. A side-stream of sweet mash is taken from the saccharification process to grow the yeast, while air, nutrients, temperatures and pH levels are monitored and controlled providing an economic supply of fresh yeast for the fermentation process.

Sweet mash from the saccharification process is mixed with fresh yeast in the fermentation vessels. The fermenters are agitated, providing optimal contact between the sugars and yeast, while temperatures are regulated and nutrients provided to maintain a controlled fermentation rate.

Yeast converts the $C_6H_{12}O_6$ glucose molecule into 2 molecules of C_2H_6O ethanol and 2 molecules of CO_2. The CO_2 can be recovered and sold as bottled gas for the beverages industry or is vented through a gas scrubbing system to atmosphere.

GEA Wiegand's pilot fermentation plant is available for trials in our R&D centre, giving direct control over the testing of different combinations of feed materials, enzymes, yeasts and process conditions. This state-of-the-art facility has automated controls and provides continuous on-line measurement of process conditions, while our laboratory is equipped with advanced GC and HPLC analytical equipment. The pilot plant is configured in a flexible format that permits trials in both continuous and batch fermentation modes, to determine the optimum conditions for the engineering and performance of starch-to-ethanol conversion processes.

Distillation and Rectification

Distillation systems require substantial amounts of energy and their design is therefore approached with energy conservation in mind, using combinations of multi-pressure cascades, heat recovery and thermal coupling. For example, the overhead vapours from the rectification column can be reused to heat the mash column reboiler, while the energy used to regenerate a molecular sieve dehydration unit can also be recovered in one of the columns. With an established reputation in distillation and evaporation in the alcohol and starch industries, GEA Wiegand applies the degree of proven expertise that allows the careful integration of the energy streams, setting the international benchmarks in process design.

Distillation starts in the mash column, where a clear ethanol and water mixture is separated from the alcoholic mash provided by the fermenters. Rectification is the activity of purifying and removing as much water as possible from the ethanol to within a few percent of the azeotropic equilibrium.

Since mash columns have to deal with the unfermented solids contained in the mash, their design is largely determined by the heat sensitivity and fouling characteristics of the type of mash being processed. Wheat and rye based mash is particularly temperature sensitive due to the denaturing of the residual proteins and amino acids that lead to fouling. In this case, GEA Wiegand uses vacuum distillation columns that operate at low temperatures to ensure that the column internals remain clean and free of deposits. Operating cycles of several months are achieved in this manner with our designs when operating on wheat and rye.

Where the feedstock is less heat sensitive, as is the case for maize (corn) for example, the mash columns are designed to operate at higher temperatures and pressures, giving greater scope for multi-effect, pressure cascades and the recovery of useful heat.

Innovative Energy Integration

Another system, known as GEA Wiegand's *Ecostill*, uses the energy from the rectification to heat an evaporator that simultaneously concentrates the stillage, while providing the ethanol as overhead vapour. This system is suited to process lines where the integration of heat from other sources, such as the dryer exhaust vapours, may not be available to heat the evaporator or pre-concentrator, for example.

Ethanol Dehydration and Purification

Alcohol received from the rectification system has to have water removed to reach anhydrous – meaning without water – fuel ethanol specifications. To remove water, the mixture can be dehydrated using a molecular sieve adsorption system, by means of pervaporation using membranes and vaporisation of the water, or by means of azeotropic or entrainment distillation that makes use of a third entraining liquid to extract water from the ethanol.

Molecular Sieve Technology

Molecular sieves, or adsorption, represent current state-of-the-art technology for low energy dehydration. The super heated ethanol/water vapour mixture is passed through a bed of zeolite beads, which provides a porous medium with very precise pore size. The pores, which are slightly larger than water molecules, attract them by electrostatic force due to the ionic properties of the zeolite and the polarity of the water vapour molecules. While the molecular sieve retains the water molecules, the larger ethanol molecules pass through the sieve bed and leave the system as dehydrated ethanol.
GEA Wiegand supplies as standard three adsorption vessels, which operate in continuous batch mode. One unit works in adsorption mode, while the other is regenerated. The third vessel allows for smoothed switching between the active adsorbing unit and the one being regenerated, allowing a gentle treatment of the zeolite and ensuring a long service life for the material. This smoothed switching also allows for steady state recovery of the energy used for regeneration, which is utilised in the distillation train.

Pervaporation

Pervaporation offers an alternative dehydration technology using hydrophilic membranes. A vacuum is created on one side of the membrane, with separation of ethanol and water determined by their differing diffusion resistances through the membrane and differences in partial pressures. Water permeates through the membrane, while dehydrated ethanol remains as the retentate. This system offers operational-versus-capital cost benefits in certain situations.

Azeotropic Distillation

Where required, GEA Wiegand provides dehydration systems using azeotropic distillation. By adding a third liquid such as cyclohexane or ethylene glycol, the azeotropic point is moved in such a way that the ethanol can be rectified while the water or ethanol is entrained by the ternary fluid. An entrainer recovery column then separates the binary mixture and recovers the entrainer component.

Stillage or Vinasse Processing

The remaining stillage or bottom product from the distillation process contains nutrients, minerals and unfermented sugars, and in the case of cereal feedstocks, a high proportion of protein, fats and fibre. These constituents occur in greater concentration than in the original raw material and are therefore valuable as animal feed, providing an additional revenue stream from the distillation process.

A range of processing options is available, determined by the degree to which the value of the co-products can be increased. Wet spent grains have a limited shelf life and must be transported to animal feedlots within close proximity of the distillery. On the other hand, DDGS (distiller's dried grains with solubles) has a higher value in that it can be handled, stored and transported to satisfy international demand from beef, dairy, pig and poultry feed markets.

Decanting

Decanting centrifuges mechanically dewater the spent grains carried in the stillage. Thin stillage, containing both dissolved and suspended solids, is produced as the centrate. Some of the thin stillage is recycled as backset to the fermentation process, where it reduces the pH of the mash and lowers the risk of infection, while providing nitrogen and nutrients that assist in the fermentation process. The remaining thin stillage, normally with a concentration ranging between 5 and 10 % TS (total solids), is then concentrated in an evaporator to produce the so-called condensed distiller's solubles ingredient of DDGS.

Drying

The decanting centrifuges simultaneously produce a wet cake of spent grains, or WDG (wet distiller's grains), which is either sold as cattle feed or processed further in a dryer to produce the more valuable DDGS. Product quality has improved in recent years as producers recognise the benefit of advanced drying systems that limit protein denaturing and improve animal digestion rates. This is achieved by improved management of drying temperatures and residence times, and by limiting the fibre content (bran) in the product to increase its suitability for monogastric (non-ruminant) digestion.

Evaporation

Falling film evaporators are used to pre-concentrate the thin stillage. Depending on the energy situation, these can be

heated using multiple effects, heated with dryer exhaust vapour where this is of sufficient quality, or by using an MVR (mechanical vapour recompression) system.

The integration of the energy streams between the dryer exhaust vapour and evaporator heating requirements is a feature of GEA Wiegand's DDGS process plants. The dryers are designed to operate at optimal efficiencies in a closed loop, gas recycle mode. This limits the amount of dry air and raises the dew point temperature of the exhaust vapour. The energy in the exhaust can therefore be utilised as the heating source for the evaporation plant, recovering condensate for use as makeup water and reducing the vapour plume, while evaporating the thin stillage. Non-condensables and volatile organic gases are combusted in the process, removing odours from the emissions.

MVR systems represent state-of-the-art in evaporation technology where dryer exhaust vapour is unavailable or of insufficient quality. The latent heat contained in the vapour is effectively recycled by means of an MVR fan, which requires a fraction of additional power in relation to the quantity of latent heat contained within the recycled vapour. Specific power consumption for MVR systems can be as low as approximately 12 kW per tonne of water evaporated.

To reach higher syrup concentrations (and viscosities), forced circulation evaporator effects are combined with the falling film pre-evaporator in a counter flow configuration. Depending on the feed material, its temperature sensitivity and the extent to which viscosity reducing enzymes are used, GEA Wiegand evaporators normally achieve final product concentrations of between 28 % and 42 %.

Condensate Recovery

Process condensates are recovered and recycled as process makeup water. Since the condensate streams contain unwanted organic substances and are slightly acidic, these are treated using combinations of biological and/or membrane separation plants. Up to 80 % of the condensate streams are recovered in this manner.

Biomass to Energy Conversion

The mass and energy balance of the bioethanol process is such that an energy surplus exists, permitting the biomass residues to be converted into renewable energy. This can be provided as heat for the process and electrical power where required.

The use of combined heat and power (CHP) cogeneration facilities has grown significantly in recent times. The combination of a CHP plant built in close proximity to an industrial heat user, especially where the heat demand is constant as is the case in a distillery, enables the heat contained in the exhaust streams of the power plant to be utilised in the process. Cogeneration improves the power cycle efficiency in a simple condensing turbine from about 20 %, to potentially more than 80 %. These efficiency gains coupled with increasing energy costs and government sponsored climate change incentives have spurred the growth of what is now a recognised industry, providing small to medium cogeneration power plants within large energy intensive installations. The environmental benefits of a CHP plant are enhanced to an even greater extent when utilising biomass fuels; the fuel source is renewable and reduces further the net CO_2 emissions when compared against fossil fuels.

Financial support for the funding of cogeneration plants is available in the form of enhanced capital allowances, reductions in climate change levies, and the trade in *carbon credits* within the EU Emissions Trading Scheme (ETS), as governments endeavour to meet their climate change and CO_2 reduction obligations under the Kyoto protocol. Depending on the jurisdiction, plants are assessed against international benchmarks for their efficiency and their effectiveness in achieving climate change targets in order to qualify for the relevant incentives. The ETS also applies to operations outside of the EU through a joint implementation and clean development mechanism, which enables the trade of credits with countries outside of EU borders.

Biomass Combustion

Cogeneration technologies have been applied for many years in the sugar-to-ethanol industry, where boilers combust the sugar cane bagasse, producing steam to drive power generating turbines. Excess power is exported to the electrical distribution grid, while steam is provided to heat the process.

Similarly, this principle can be applied in cereals-to-ethanol processes, using specialist biomass combustion and CHP co-

generation technologies. Steam turbines are used which generate renewable electricity, while providing high and low pressure pass-out steam in the quantities as required by the distillery design.

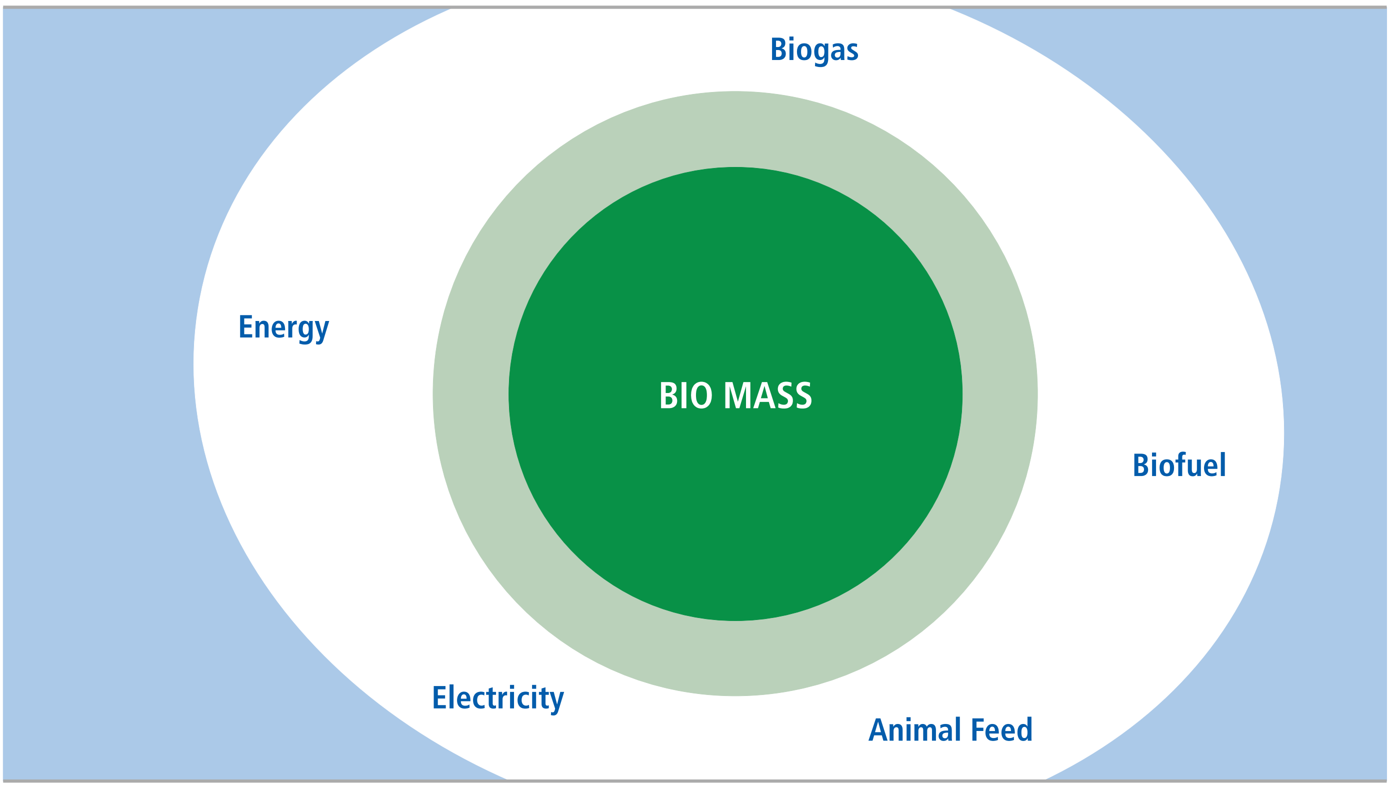
Biogas Production

Another strategy is to use anaerobic digesters to produce methane rich biogas from the biomass and/or thin stillage streams. The biogas is then utilised as either CHP boiler fuel, producing steam to heat the ethanol process and, if required, to generate renewable electricity, or to provide the heat source for the DDGS dryer. Advanced superheated steam drying systems permit the utilisation of medium grade, exhaust steam from the dryer to be used as energy in the process, capable of providing the heating source for the evaporator and parts of the distillation process.

In large-scale installations, the availability of sufficient quantities of biogas may allow the economic use of a more efficient combined cycle cogeneration plant, where a gas fuelled engine or turbine produces electrical power for export to the grid, while the engine's exhaust heat is recovered in a waste heat boiler for use in the process.

With the possibility of providing alternative fuel burners, the final DDGS co-product mix can be balanced between seasonal demand for animal feeds and energy prices, giving greater flexibility in response to prevailing market conditions.

As can be seen, a variety of concepts and combinations of possibilities exist, which can very much influence the success of a bioethanol operation. GEA Wiegand would be pleased to assist from the very initial planning stage of your project, assisting in the decisions that are required to find the most suitable production strategy. In this way, we are able to partner with our clients, responding to their particular requirements while taking into account the availability of resources, utilities and site-specific conditions, to deliver an optimised and reliable installation.



Overview on our Range of Products

Evaporation plants
to concentrate any type of fluid food, process water, organic and inorganic solutions and industrial waste water; with additional equipment for heating, cooling, degassing, crystallization and rectification.

Membrane filtration – GEA Filtration
to concentrate and process fluid food, process water, industrial waste water, to separate contaminations in order to improve quality and recover valuable substances.

Distillation and rectification plants
to separate multi-component mixtures, to recover organic solvents; to recover, clean and dehydrate bio-alcohol of different qualities.

Alcohol production lines
for potable alcohol and dehydrated alcohol of absolute purity; integrated stillage processing systems.

Condensation plants
with surface or mixing condensers, to condense vapour and steam/gas mixtures under vacuum.

Vacuum / steam jet cooling plants
to produce cold water, to cool liquids and product solutions, even of aggressive and abrasive nature.

Jet pumps
to convey and mix gases, liquids, and granular solids; for direct heating of liquids; as heat pumps; and in special design for the most diverse fields of application.

Steam jet vacuum pumps
also product vapour driven; also in combination with mechanical vacuum pumps (hybrid systems); extensive applications in the chemical, pharmaceutical and food industries, in oil refineries and for steel degassing.

Heat recovery plants
to utilize residual heat from exhaust gases, steam/air mixtures, exhaust steam, condensate and product.

Vacuum degassing plants
to remove dissolved gases from water and other liquids.

Heating and cooling plants
mobile and stationary plants for the operation of hot-water heated reactors and contact driers.

Gas scrubbers
to clean and remove dust from exhaust air, to separate aerosols, cool and condition gases, condensate vapours and absorb gaseous pollutants.

Project studies, engineering for our plants.

GEA Process Engineering

GEA Wiegand GmbH

P. O. Box 100949, 76263 Ettlingen, Germany
Tel.: +49 7243 705-0, Fax: +49 7243 705-330
gea-wiegand.info@gea.com, www.gea-wiegand.com

P11E HINKEL360