

EISENMANN



BIOGAS PLANTS



FOR MANY FARMS, WASTE-DISPOSAL COMPANIES AND LOCAL GOVERNMENT AGENCIES, IT MAKES SOUND ECONOMIC AND ECOLOGICAL SENSE TO INVEST IN BIOGAS PLANTS. THEY CAN GENERATE ENERGY FROM ANIMAL MANURE, ENERGY CROPS AS WELL AS FOOD PRODUCTION, CAFETERIA AND GREEN WASTE. MOREOVER, MANY COUNTRIES SUBSIDIZE GREEN ENERGY, IMPROVING THE RETURNS TO BE GAINED FROM BIOGAS PLANTS.

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GENERAL INTRODUCTION TO BIOGAS

Biogas plants – a key role to play in renewable energy

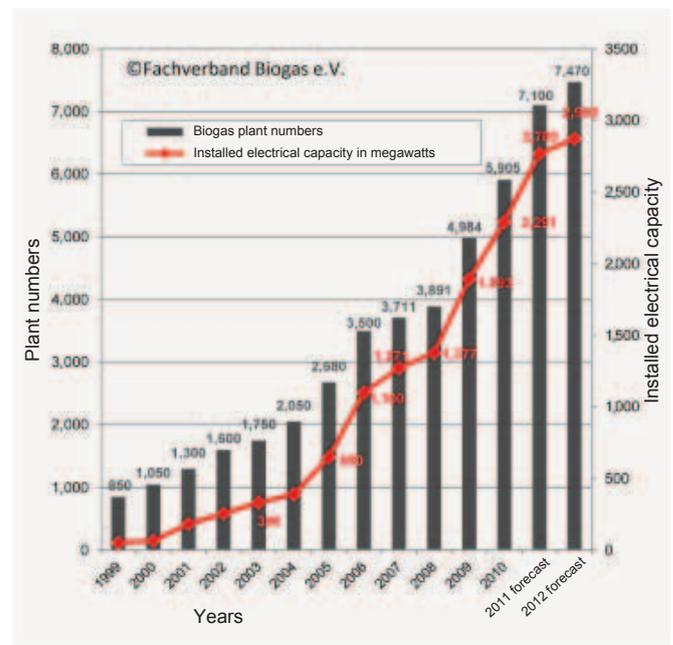
Controlled anaerobic digestion of organic materials can be harnessed to generate biogas. Biogas is an eco-friendly alternative to fossil fuels. It can, for example, be used to fuel a combined heat and power (CHP) plant. A further possibility is to upgrade biogas to natural-gas quality that can be fed into the pipeline system or compressed and used to fuel vehicles.

Drivers

- Subsidies and grants
- Legislation promoting recycling
- Growing public and political call for renewable energy
- Combined heat and power technology
- Climate protection

Advantages

- Multiple end-products: gas, vehicle fuel, raw materials for subsequent processes, electricity, heat, easy-to-store energy
- Energy independence
- Local deployment
- Regional value creation
- Closed-loop energy and nutrient cycles



Development of biogas plant numbers in Germany, and total installed electrical capacity in megawatts; 11/2011.



EISENMANN – THE BIOGAS EXPERTS

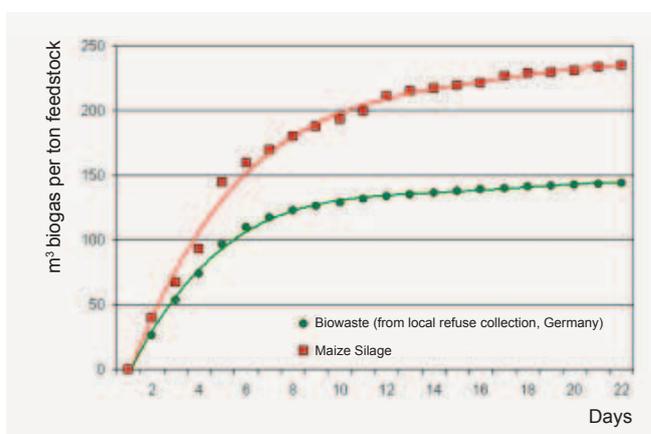
Eisenmann Environmental Technology offers a one-stop portfolio of state-of-the-art, highly efficient environmental engineering systems. Drawing on 60 years' experience in industrial plant engineering, we design and build customer-specific plants worldwide for:

- Waste water
- Exhaust air
- Hazardous waste incineration
- Ammunition disposal
- Wood gasification
- Biogas

The very first Eisenmann plant for the commercial production of biogas was commissioned in 2003. It featured a horizontal plug-flow digester and steel post-digester. These plants are ideal for agricultural waste and renewable feedstock, such as silage.

Since 2008, the proven Eisenmann plug-flow digester has also been available for biowaste. This required significant changes to plant configuration due to the varying properties of the feedstock. Eisenmann is able to draw on its long and successful track record in industrial plant engineering to deliver high

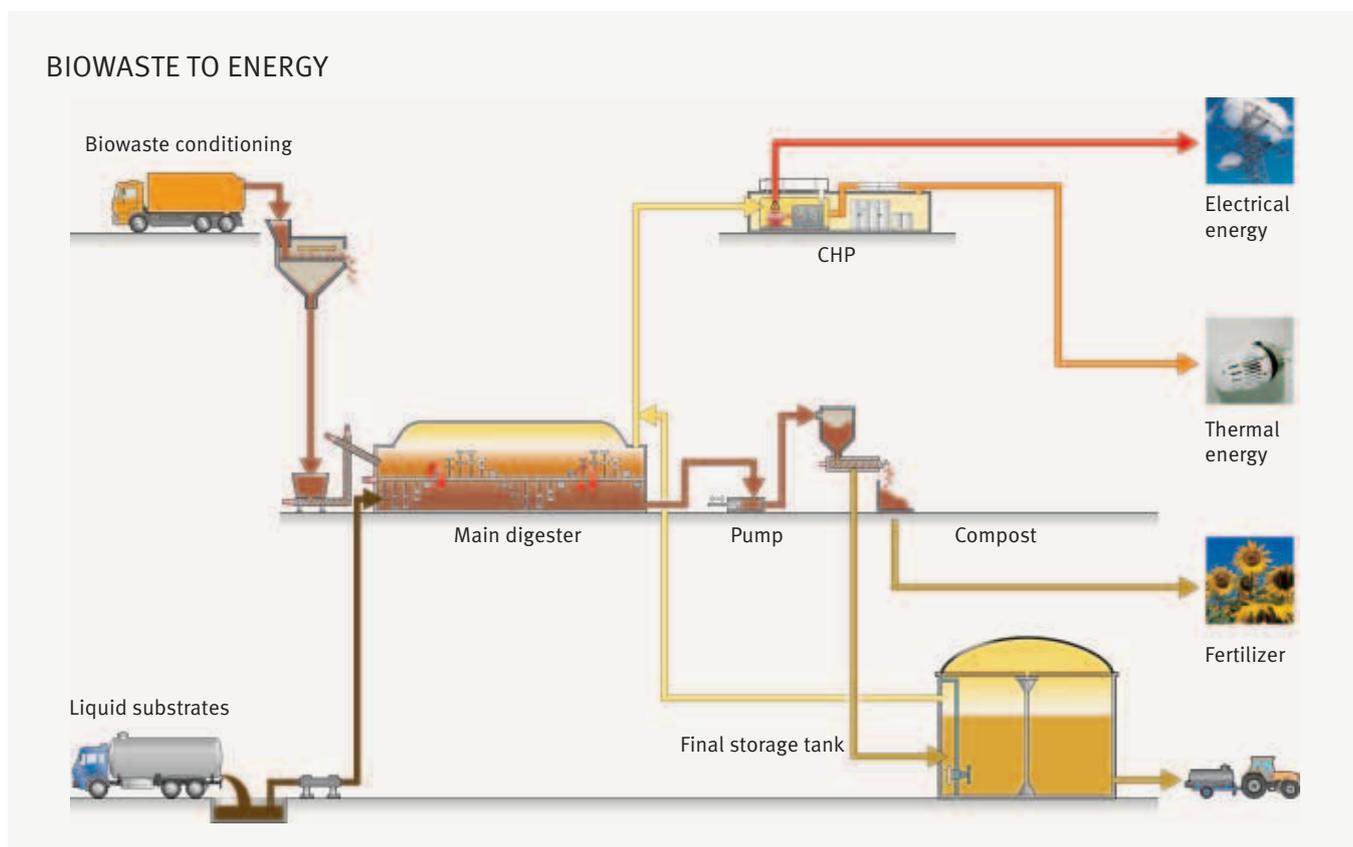
quality and compliance with all applicable safety standards. Highly professional project managers and experienced after-sales service experts ensure smooth, swift installation and reliable operation.



Gas yields from maize silage and biowaste (from local refuse collection, Germany).



BASIC PRINCIPLES OF BIOGAS PRODUCTION



BIOGAS PLANTS FOR USE ON FARMS

Standard Eisenmann biogas plants are based on a two-stage process, with a main and post-digester. The main digester is of horizontal design, made of steel, heated and thermally insulated. The plug-flow digester is fitted with a horizontal agitator along its entire length. In terms of microbiology, the plug-flow process is a highly effective method of generating biogas from organic matter. Plug-flow operation ensures that the biological processes take place under ideal conditions – maximizing gas yield and ensuring reliable, uninterrupted operation.

After the main digester, the substrate is passed to the post digester for a second digestion stage. The post digester is a heated, thermally insulated vertical stirred tank with a top-mounted double-membrane gas holder, storing the biogas before use. The fully digested substrate is pumped from the post-digester to a digestate storage tank prior to being spread as fertilizer.

Features of the standard Eisenmann biogas plant:

- Plug-flow process for feedstock with maximum dry matter contents
- High gas yield in conjunction with high process stability
- Main digester available with a capacity of 270, 325 or 400 m³, expandable through add-on modules
- Consistent industrial quality, irrespective of location
- More than 70 plants already successfully installed
- Short lead times and extremely rapid on-site construction thanks to prefabricated components



PLUG-FLOW DIGESTER FOR BIOWASTE

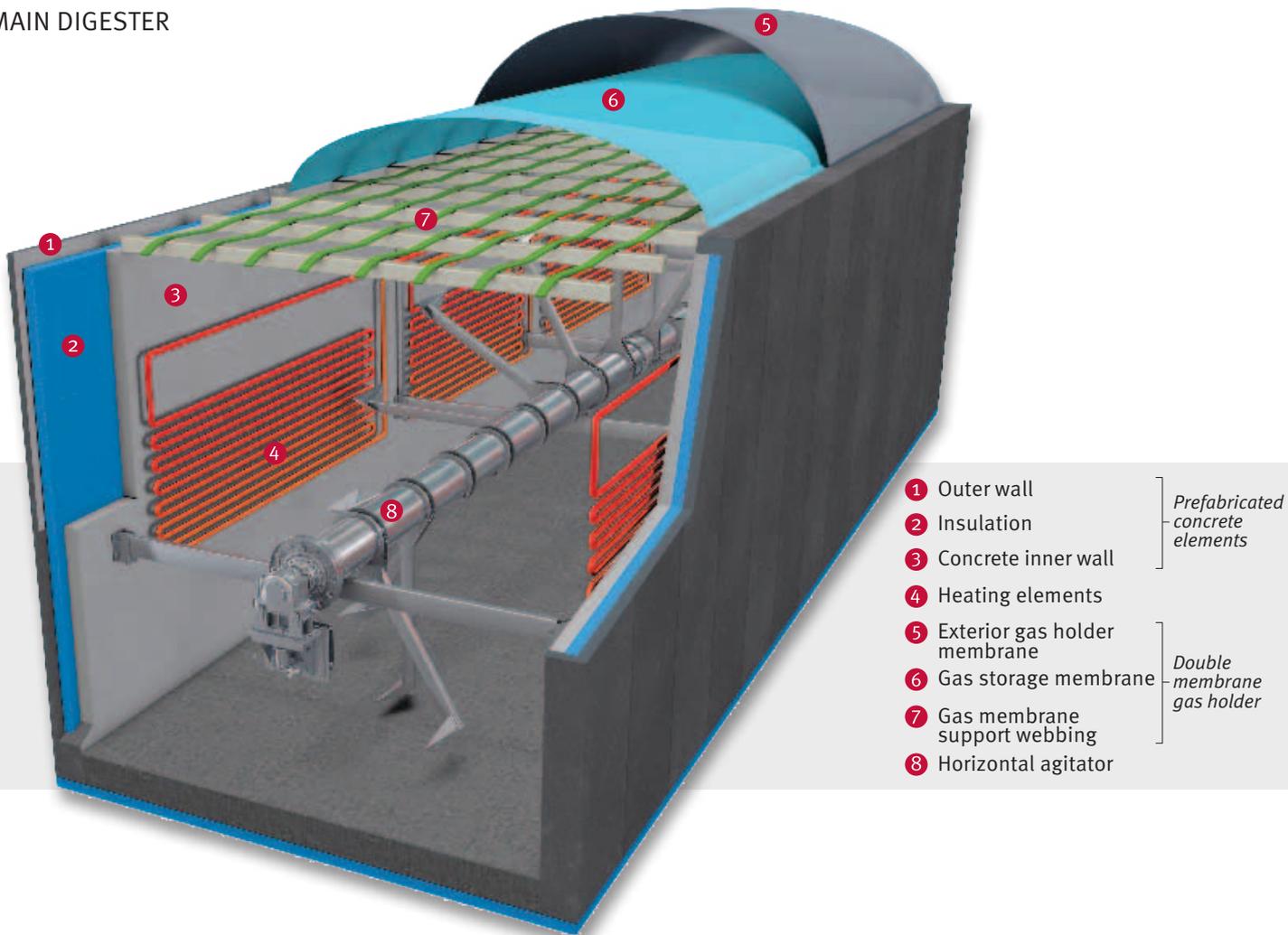
Eisenmann plug-flow digester

The central feature of the Eisenmann biowaste plant is the horizontal plug-flow digester. This design delivers the best possible digestion results and reliable operation. The design prevents short-circuiting of feedstock, ensuring maximum biogas yield. The Eisenmann system design provides sufficient residence time to ensure full biowaste sanitization, allows high organic loads and continuous high solids digestion.

Advantages at a glance

- Customer-specific solutions
- 60 years' experience in industrial plant engineering
- Digestion of high-solids feedstocks
- High organic load with ideal residence time
- Maximized gas yield
- Minimized recirculation rates
- Sanitization in accordance with applicable legislation
- Rapid on-site construction
- Enclosed system prevents emission of offensive odors

MAIN DIGESTER



Double-membrane gas holder

The roof of the digester comprises a removable double-membrane gas holder with a gas-level indicator that is used to control the gas utilization rate. A fully enclosed biogas system ensures complete safety when producing and handling biogas.

Pressure-tight doors

Strategically placed pressure-tight doors ensure easy access for maintenance and inspection.

Control system

Industrial-standard control system in conjunction with continuous monitoring and recording of all relevant process parameters, enabling fully automated operation and exceptional reliability.

Safety systems

Comprehensive, highly effective safety systems in accordance with applicable local legislation and standards.

Horizontal agitator

The horizontal agitator ensures thorough mixing of the feedstock and prevents the formation of floating scum. Continuous agitation frees gas from the homogenized material.

Design features

- External bearing, separated from sealing system
- Monitoring of rotational speed and torque
- Frequency-controlled drive with planetary gear
- Continuous lubrication via automatic grease pumps
- No central bearing required due to floating hollow shaft

Heating

Heating elements with separate heating circuits ensure precise, even temperatures and reliable sanitization.

Separation

Screw-press separators of various types available, depending on feedstock and customer requirements.



BIOGAS UPGRADING WITH MEMBRANE TECHNOLOGY

Biogas upgrading

Eisenmann employs membrane technology to upgrade raw biogas from 50 - 65% methane by volume, plus carbon dioxide, to biomethane of natural-gas quality. This biomethane can be fed into natural gas pipeline system, compressed for use as a vehicle fuel or employed to generate heat. Upgrading to biomethane creates an easy-to-store and flexible source of energy.

Eisenmann membrane technology

After pre-treatment, the raw biogas stream is compressed to more than 10 bar and methane is concentrated by means of a multi-stage configuration of membrane modules. By employing highly selective hollow-fiber membranes it is possible to achieve a methane concentration of more than 97% by volume. After upgrading, the biomethane is dry and meets the dew-point criteria of pipeline natural gas.

Advantages

The exceptionally selective and permeable membranes minimize gas recirculation rates, with the following advantages:

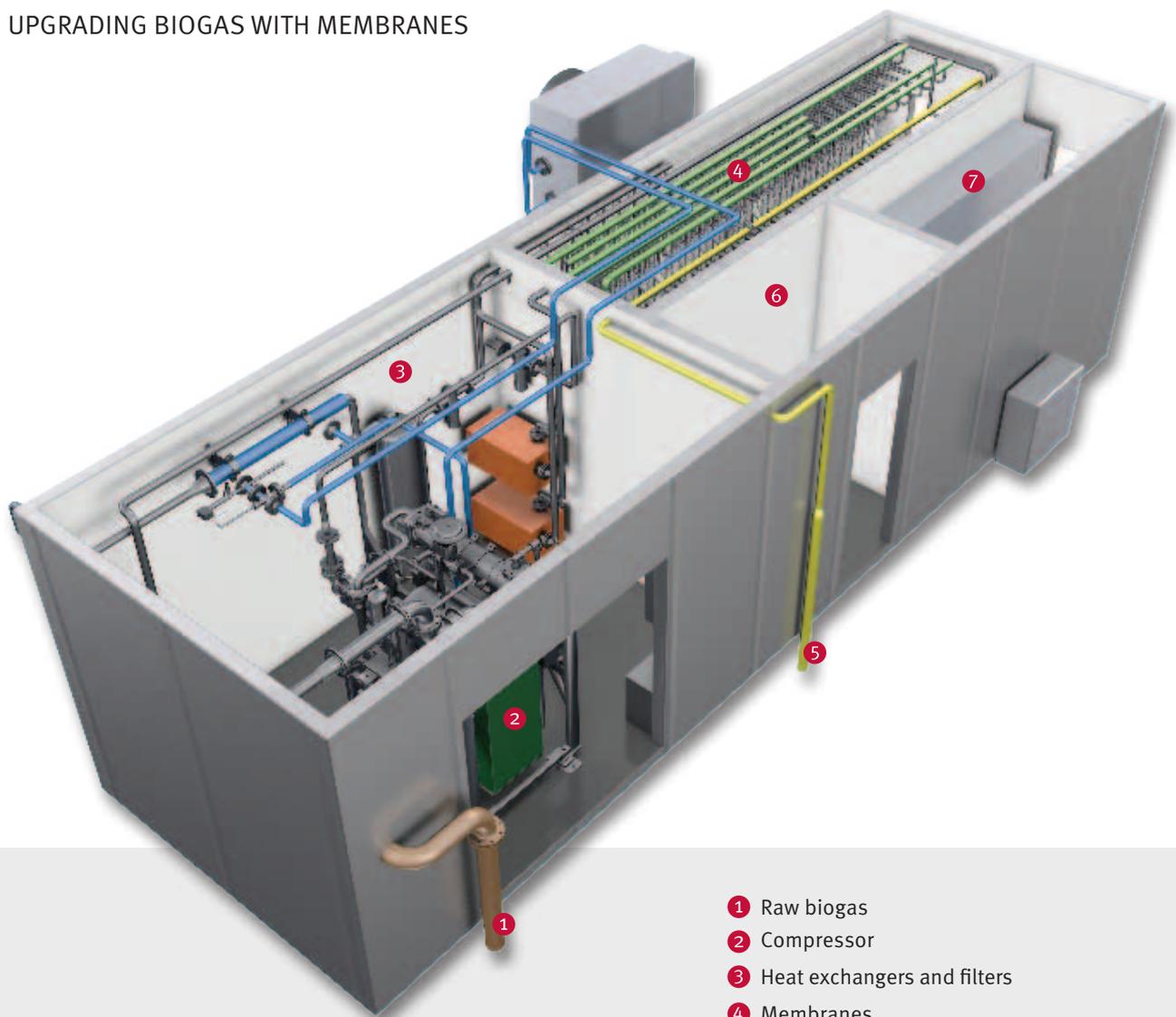
- Lower operating costs
- Low capital expenditure
- Modular design
- Rapid system start-up
- Easier system control
- Low methane leakage
- No need for additional consumables

Reference biogas upgrading, Pratteln, Switzerland

In the third quarter 2012, Eisenmann will be installing a biogas upgrading system with highly selective membranes for an existing customer in Switzerland. The system has a throughput of 210 Nm³ of raw biogas per hour. The biomethane is sold as compressed vehicle fuel (CNG) at the local natural gas fueling station.



UPGRADING BIOGAS WITH MEMBRANES

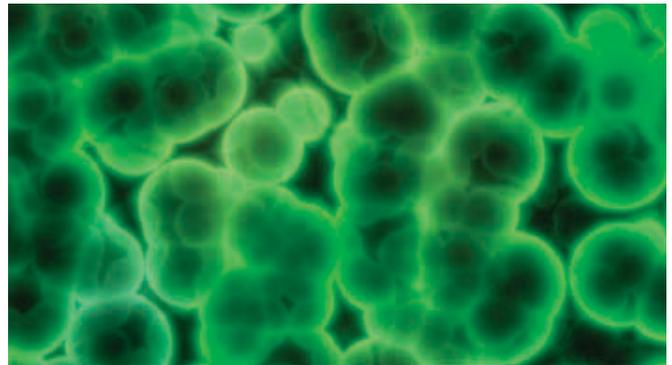


- ① Raw biogas
- ② Compressor
- ③ Heat exchangers and filters
- ④ Membranes
- ⑤ Biomethane pipeline feed-in to public grid
- ⑥ Gas analysis room
- ⑦ Control cabinet

BIOGAS PLANT CONSULTING

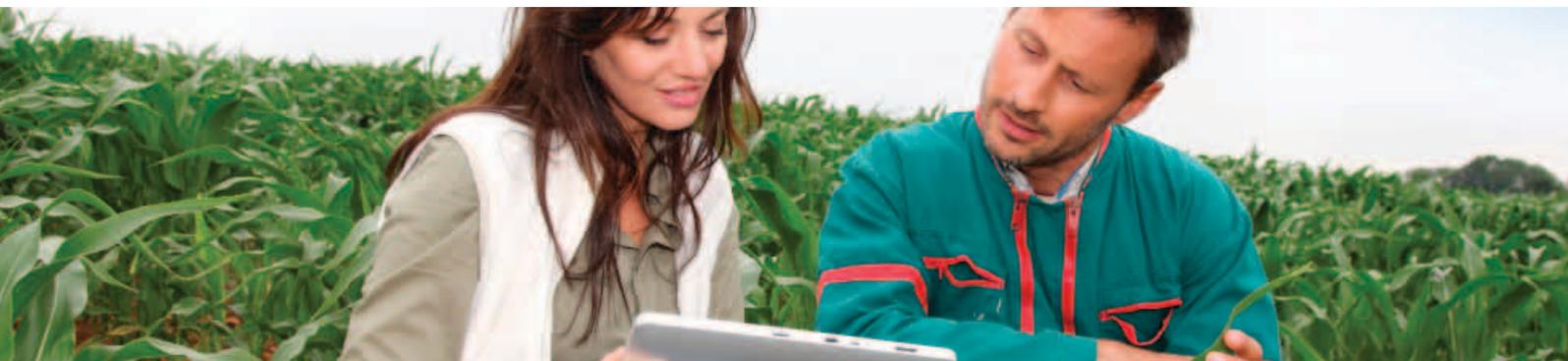
The goal of our consulting services is to ensure the biogas plant is operated to deliver the best possible results. We conduct tests on the feedstock, and provide corresponding recommendations. This is followed by a controlled start-up phase in conjunction with monitoring and analysis.

Drawing on our experience with many comparable plants, we can then make specific recommendations on gas yield potential, biological issues and trace elements. We can also offer expert advice on alternative feedstock, and on plant modifications or expansions. Close collaboration with our Service unit helps ensure maximum system uptime and consistently high performance.



We offer you:

- Advice on and recommendations for feedstock
- Tailor-made start-up plan
- Analysis of all biologically relevant operating parameters
- Recommendations on best-practice plant operation
- Optimization of plant operation by means of plant monitoring and analysis



SERVICE

Eisenmann offers a broad service and support portfolio. Our services are tailored to the specific needs of the customer, taking into account in-house staff skills and customer cost structures. We believe in creating a true partnership, driven by customer imperatives.

- Inspection
- Maintenance
- Repairs
- Remote diagnosis
- Stand-by support
- Maintenance contracts
- Full-service solutions

Our Service is dedicated to making you and your plant successful.



ANCONA BIOGAS PLANT

| Technical data | |
|--------------------------------|--|
| Year constructed: | 2009 |
| Feedstock: | cattle slurry, cattle manure, dry chicken manure, olive press cake, straw and hay, grass and corn (maize) silage |
| Feedstock throughput: | 9,000 t/d |
| Main digester capacity: | 270 m ³ |
| Post-digester capacity: | 750 m ³ |
| Nominal biogas flow rate: | 120 Nm ³ /h |
| Installed electrical capacity: | 249 kW |



CREMONA BIOGAS PLANT

| Technical data | |
|---------------------------------------|--|
| Year constructed: | 2010 |
| Feedstock: | slurry, chicken manure, diverse types of silage, olive press cake, waste animal feed, liquid organic waste |
| Feedstock throughput: | approx. 33 t/d |
| Digester capacity: | Main digester: 2 x 325 m ³ Post-digester: 1 x 2,000 m ³ |
| Nominal biogas flow rate: | approx. 280 - 300 Nm ³ /h |
| Installed electrical capacity: | 620 kW |





Liesberg biogas plant.

LIESBERG BIOGAS PLANT

After less than a year's construction work, Eisenmann handed over a state-of-the-art biogas plant to Kelsag Biopower AG, in Liesberg in Switzerland, in spring 2011. An existing composting facility was incorporated into the new end-to-end solution, allowing the co-generation of heat and power – and the production of digestate to be used as fertilizer. The plant is designed to process 12,000 metric tons of regional biowaste annually.

| Technical data | |
|---------------------------------------|--|
| Year constructed: | 2010 |
| Feedstock: | yard waste, biowaste, waste from the food industry |
| Feedstock throughput: | 12,000 t/year |
| Main digester capacity: | 800 m ³ |
| Nominal biogas flow rate: | 150 Nm ³ /h |
| Installed electrical capacity: | 330 kW |



THIS IS EISENMANN

Eisenmann designs and builds plants for surface finishing, material flow automation, environmental technology, firing lines for ceramics and special installations for coating, recycling, thermal treatment and energy recovery.

Approximately 3,600 employees worldwide, half of them engineers or technicians, develop new ideas in the areas of production, painting, assembly and distribution. Among them are experts and specialists with solid knowhow in various areas of expertise and industry sectors. This is an advantage that results in customized concepts with state-of-the-art technology and a high degree of economic efficiency.

Another result of our efficient production and assembly strategies: Our production centers are tailored to the individual requirements of our customers. We design a plant configuration especially adapted to your needs.

When complex systems are involved, we assemble the entire plant in our factory before delivering it, and we put the system to the acid test. Only when the preassembled function modules have passed the test run will they be handed over to the customer. This method saves considerable time and cost for assembly and commissioning on site and enables the installation in your plant without even interrupting your production process.

Of course, we will assist you after commissioning at your demand: Our Aftersales Service provides professional maintenance, short repair times and immediate provision of spare parts.



Eisenmann technology center in Holzgerlingen.



NOTES

A large grid of small dots for taking notes, consisting of 30 columns and 40 rows of dots.

EISENMANN

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