BIOGAS ENERGIZED BY

LANXESS
Energizing Chemistry

Innovative iron oxide for desulfurizing biogas – **Bayoxide® E 16**

Bayoxide®

ENERGY SUPPLY: STRONG GROWTH IN BIOGAS PLANTS

Biogas is a trend today because it is an ecological, resource-conserving and climate-neutral energy source. Germany alone currently has around ten times as many biogas plants as it did 13 years ago. More than 8,000 plants with an installed capacity of nearly 3,000 megawatts now contribute to the energy supply.

How a biogas plant works

In a biogas plant, organic substances are decomposed and fermented under anaerobic conditions, i.e. in the absence of oxygen. The plants process materials such as crops, waste from livestock such as slurry, agroindustrial residues and biowaste from commercial businesses and households. Fermentation produces a gas comprised chiefly of methane, which in most cases is used directly on site to drive a generator. Depending on the starting materials, biogas contains fluctuating levels of hydrogen sulfide, on average about 500 milligrams per cubic meter. The hydrogen sulfide must be removed from the gas because of its toxicity, odor and, above all, the corrosive effect of the sulfur compounds on the fermentation reactor and generator. Also, without desulfurization, the limit values for formaldehyde would be exceeded as a result of the inactivation of the catalytic exhaust gas converter.

In addition to biowaste and waste from livestock, crops are also used as biogas feedstock.

INNOVATIVE IRON OXIDE FOR DESULFURIZING BIOGAS

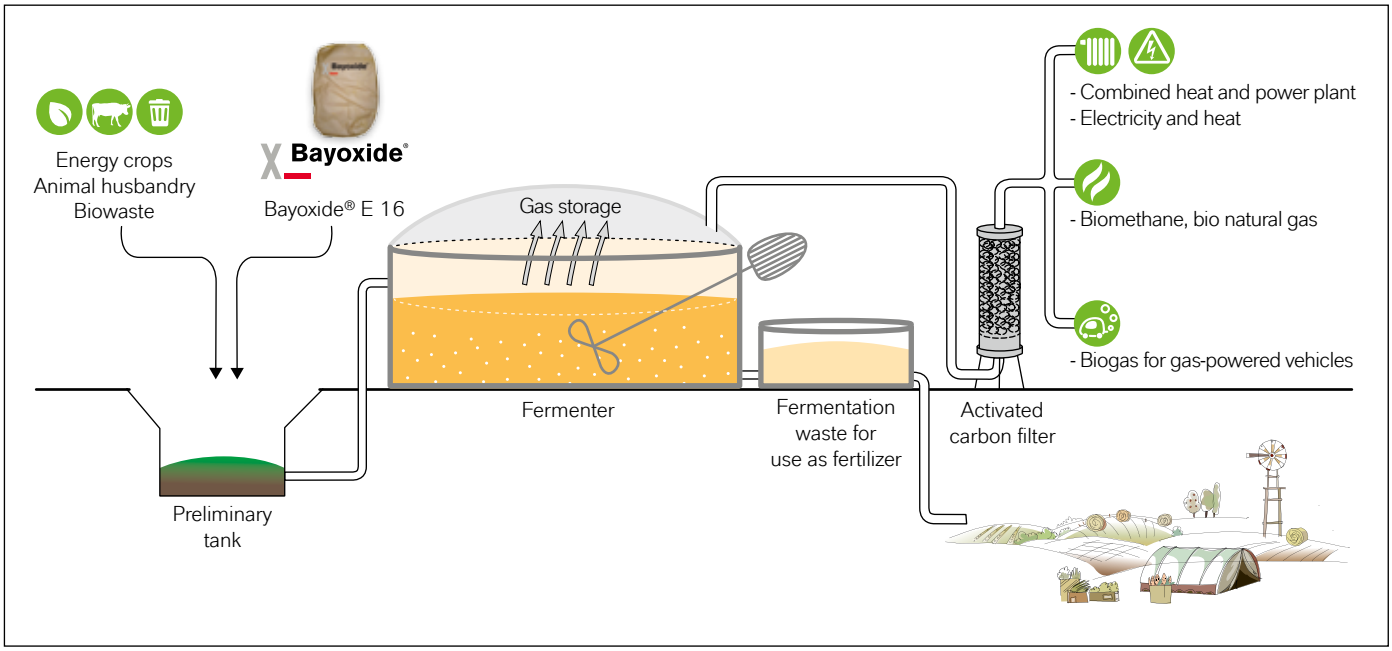


Diagram showing how Bayoxide® E 16 is used

Bayoxide® E 16 is a highly effective synthetic iron oxide developed by the specialty chemicals company LANXESS for lowering the hydrogen sulfide content of biogas. It can be added directly to the fermentation reactor.

An innovative iron oxide – Bayoxide® E 16

Bayoxide® E 16 is a cost-effective alternative to conventional desulfurization processes. It removes much of the hydrogen sulfide (H_2S) in the fermentation reactor, and is highly effective due to its almost 100 percent purity. Unlike many other desulfurization methods, no metering systems are required, which makes the application very straightforward. Fermentation produces harmful H_2S, which is removed by the innovative industrial-grade iron oxide Bayoxide® E 16. As a result, environmentally friendly biogas can replace fossil fuels in the energy mix.

BENEFITS OF BAYOXIDE® E 16

In addition to offering numerous benefits in terms of handling, storage and metering, Bayoxide® E 16 is safe and easy to use.

Avoiding corrosion damage

Using Bayoxide® E 16 avoids corrosion damage caused by the sulfuric acid that frequently forms with the widespread practice of feeding in air to remove hydrogen sulfide.

Safe handling

Iron oxide is neither a hazardous material nor a water contaminant, and can be handled using simple equipment and without expensive metering systems. Plants sustain no corrosion damage, the product requires no special storage, and personnel do not need to be trained in accordance with the national regulations for the handling of dangerous goods.

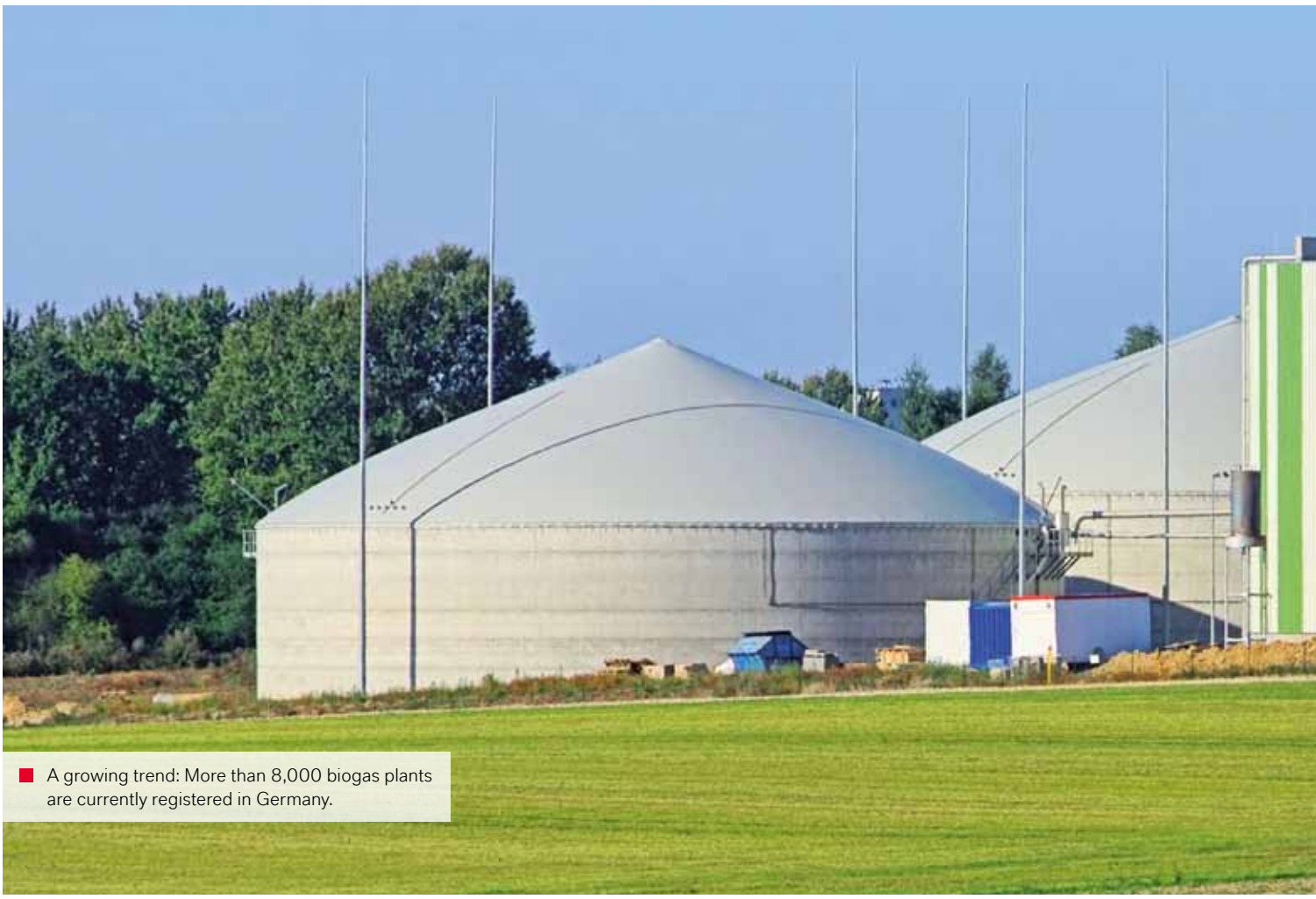
No risk of explosive mixtures

The risk of explosive mixtures of methane and oxygen forming as a result of adding an incorrect, excessive amount of air can be ruled out.

Compliance with fertilizer guidelines

Bayoxide® E 16 reacts with hydrogen sulfide to form iron sulfide, which occurs naturally in soil and can be used to fertilize fields, together with the fermentation residue. Bayoxide® E 16 benefits from high purity and is produced under strictly controlled conditions, thereby ensuring consistently high quality.

Thanks to its high purity, Bayoxide® E 16 complies with the strict guidelines of the DüMV (German Fertilizer Regulation).



A growing trend: More than 8,000 biogas plants are currently registered in Germany.

Easy metering

Bayoxide® E 16 prevents hydrogen sulfide from forming in the fermentation reactor and does so without any negative impact on the biological process. It becomes fully effective after just a few days and forms a buffer that evens out fluctuations in the substrates' sulfur concentration.

Clean, dust-free handling

Bayoxide® E 16 is packed in 20 kilogram paper sacks. At most plants, these can be thrown unopened into the mash pit or the conveyor system of the fermentation reactor. The package size enables clean and incredibly easy material metering. For safety reasons, it is necessary to check before adding entire sacks whether the fermentation reactor´s pipe system includes screens or grids that have the potential to become blocked by paper sacks.

Lower costs for fine desulfurization

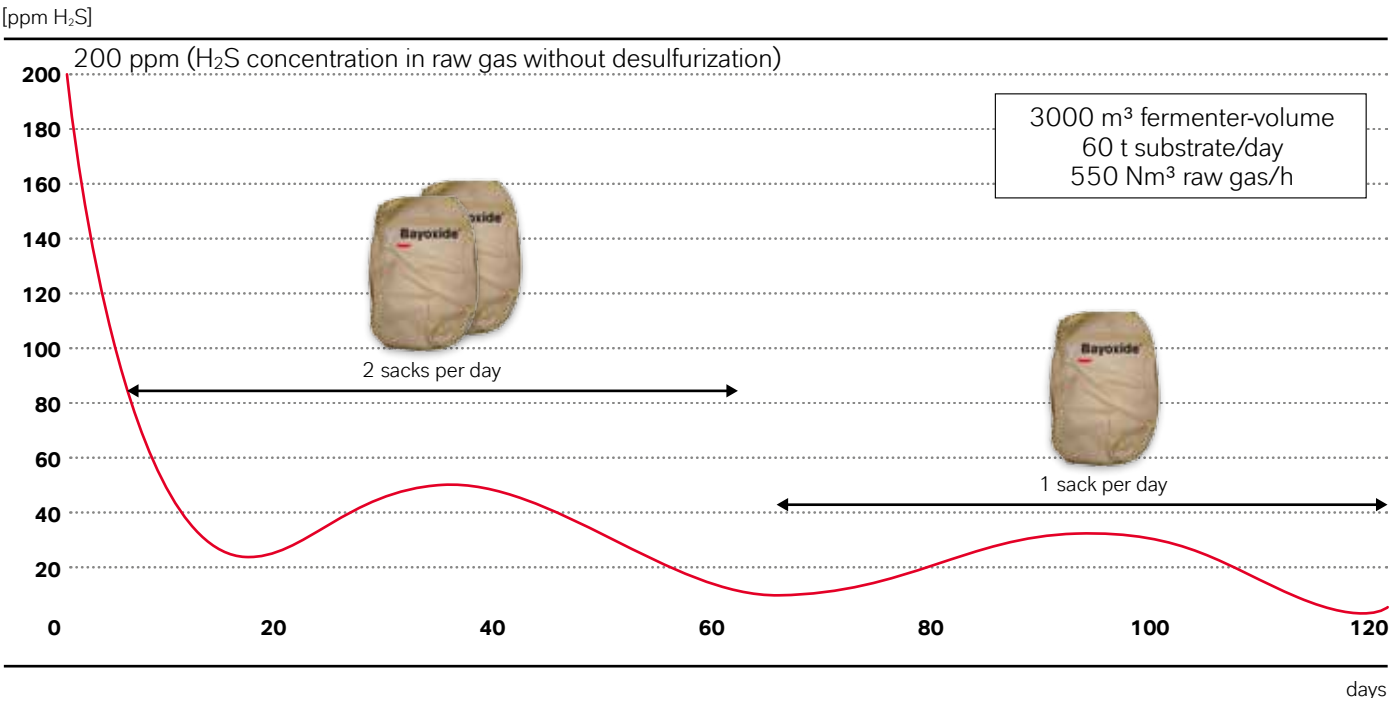
Bayoxide® E 16 effectively removes a large proportion of hydrogen sulfide in the primary fermentation reactor, therby significantly reducing the costs of any secondary 'fine' desulfurization of the biogas which may be necessary. For example, with the use of activated carbon gas scrubbers, or similar.

COMPARISON OF METHODS FOR DESULFURIZING BIOGAS

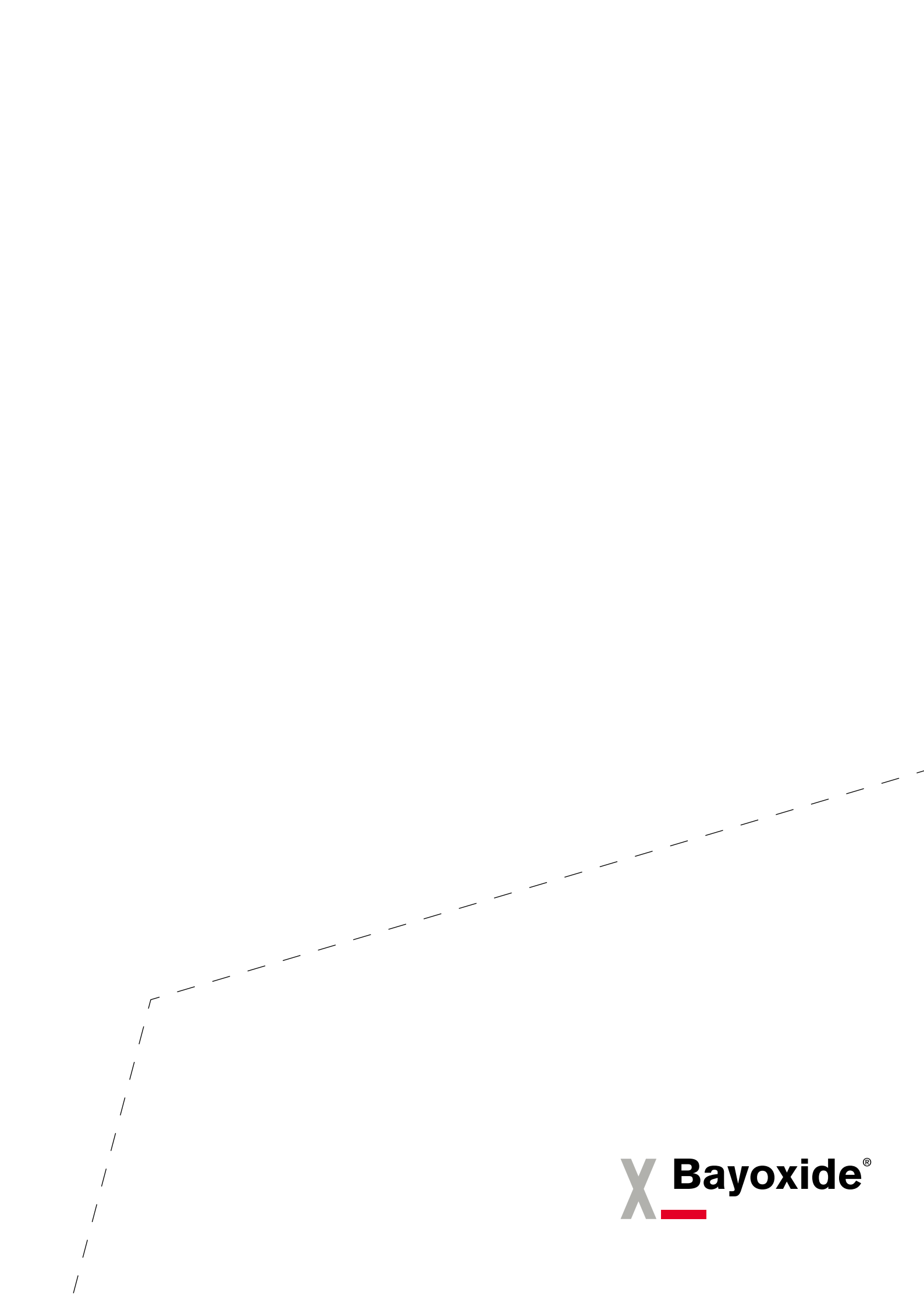
The overview illustrates the benefits of using Bayoxide® E 16 rather than alternative biogas desulfurization methods.

	Bayoxide® E 16	Iron chloride	Biological desulfurization
Hazardous substance	●●●	●●●	●●●
Corrosiveness	●●●	●●●	●●
Frost resistance	●●●	●●●	●●●
Handling	●●●	●●●	●●
Methane concentration	●●●	●●●	●●
Fermentation reactor biology	●●●	●●	●●
Effectiveness	●●●	●●●	●●
Risk of explosion	●●●	●●●	●
Reaction speed	●	●●●	●
Repository effect	●●	●●●	●●●
Undesirable reaction products	None	Hydrochloric acid	Sulfuric acid

SAMPLE APPLICATION OF BAYOXIDE® E 16 IN PRACTICE



Reduction of H_2S concentration during desulfurization with Bayoxide® E 16


Bayoxide®

CALCULATION OF DAILY AMOUNT OF BAYOXIDE® E 16

Essentially, the daily amount depends on the relevant parameters of the biogas plant. The following formula can be used to obtain an initial guide value:

$$\frac{H_2S \text{ concentration}^{1)} \text{ [ppm]} \times \text{gas volume [m}^3\text{/h]}}{5000} = \text{X kg Bayoxide® E 16 per day}$$

[1]) In the raw gas without desulfurization

Example 1:

$$\frac{200 \text{ ppm } H_2S \times 500 \text{ m}^3 \text{ gas/h}}{5000} = 20 \text{ kg Bayoxide® E 16 per day}$$

Example 2:

$$\frac{1200 \text{ ppm } H_2S \times 125 \text{ m}^3 \text{ gas/h}}{5000} = 30 \text{ kg Bayoxide® E 16 per day}$$

If no other desulfurization method is being used, a higher dose of Bayoxide® E 16 should be selected in the first few days to ensure adequate desulfurization from the outset. Depending on the initial situation, it is recommended to use five times the amount of Bayoxide® E 16 on the first day and two to three times the amount on the following three to five days.

TECHNICAL INFORMATION

Bayoxide® E 16 is extremely pure and is produced under strictly controlled conditions, thereby ensuring consistently high quality and compliance with the DüMV* (German Fertilizer Regulation).

Specified values

Technical data	Min.	Max.	Test method	Limits as per DüMV*
Fe content [wt%], relative to dry matter	60			
FeOOH content [wt%], relative to dry matter	95			
Bulk density [g/cm3]	0.8	1.2		
Water-soluble content [wt%]		0.5		

Trace elements	Min.	Max.	Test method	
This product complies with the provisions of the DüMV* (German Fertilizer Regulation)				
As [mg/kg]		40	Atomic spectroscopy	80
Cd [mg/kg]		1.5	Atomic spectroscopy	1.5
Cr(VI) [mg/kg]		2	Atomic spectroscopy	2
Hg [mg/kg]		1	Atomic spectroscopy	1
Ni [mg/kg]		50	Atomic spectroscopy	120
Pb [mg/kg]		20	Atomic spectroscopy	150
Tl [mg/kg]		1	Atomic spectroscopy	1

* German Fertilizer Regulation (Düngemittelverordnung) dated December 16, 2008/amendment dated December 14, 2009

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