

SEPURAN[®] Green

Membrane technology
for upgrading biogas efficiently



SEPURAN[®] Green

Gas separation with SEPURAN®

Evonik, the creative industrial group from Germany, is one of the world leaders in specialty chemicals. As a technology leader in high-performance polymers, we offer hollow-fiber membranes for efficient and energy-saving gas separation. The first product of the SEPURAN® product family is SEPURAN® Green for biogas upgrading.

Benefits

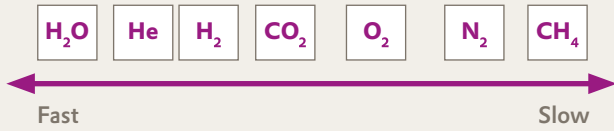
- Lower energy consumption
- No auxiliary materials such as water or sorbents required
- No emissions into the environment
- Separation at ambient temperature
- Low space requirements
- Continuous separation process
- Simple, modular setup
- Flexible and easily expanded
- Very high selectivity

Applications

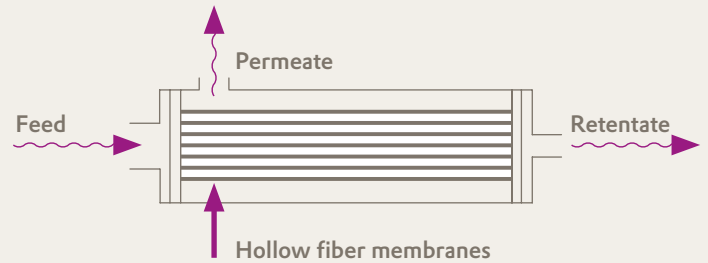
- Extraction of methane
- Upgrading of process gases
 - Nitrogen generation
 - Upgrading of H₂
 - Helium recovery



Relative permeation rates of various gases



Mode of operation of a membrane cartridge for gas separation



How does membrane-based separation work?

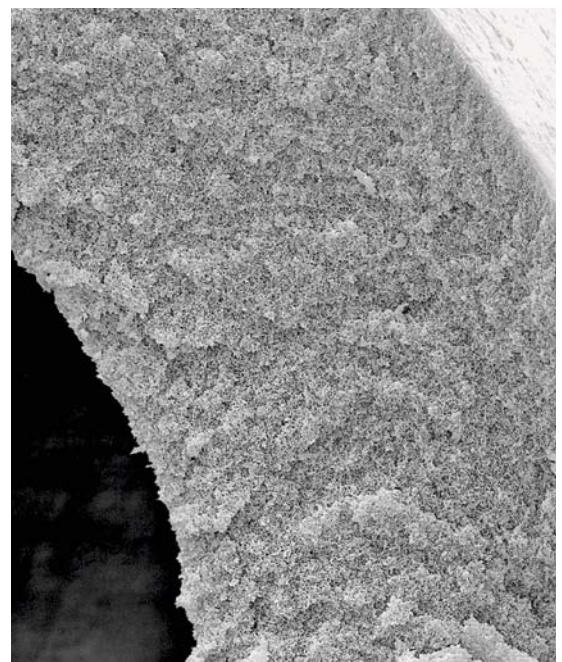
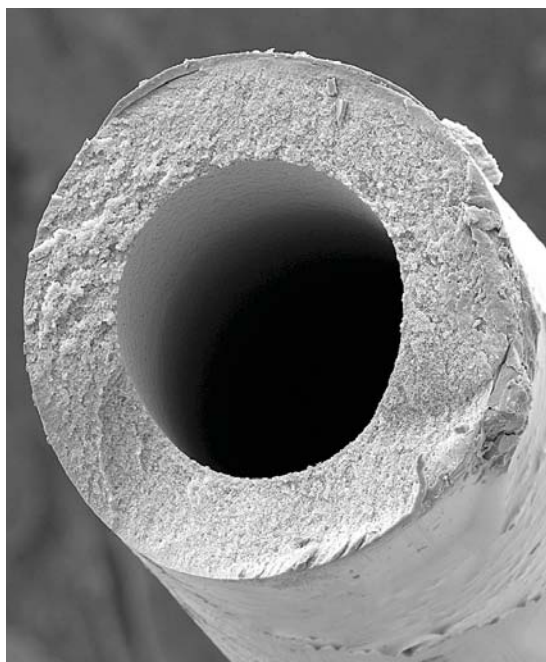
Gas separation membranes work on the principle of selective permeation through a membrane surface. The driving force for permeation of the gas through the membrane is the difference between the partial pressures of the gas on the retentate side (the interior of the hollow fiber) and the permeate side (the exterior of the hollow fiber).

The greater this difference, the higher the proportion of the gas that permeates through the membrane. In a separation, such as between carbon dioxide and methane, permeation of carbon dioxide through the membrane is much faster while methane is retained within.

The permeation rate of each gas depends on its solubility in the membrane material and on the diffusion rate. Gases that have higher solubility and smaller molecular

size permeate the membrane faster than larger, less soluble gases. The ratio of the transport speeds of two gases is called selectivity.

The higher the selectivity, the higher the energy efficiency of the resulting membrane process. Different membrane materials have different separation properties. The driving force required for the separation is obtained through a partial pressure gradient.



Our product – The SEPURAN® Green cartridge

The SEPURAN® product family includes membrane systems for gas separation in various applications. The SEPURAN® Green cartridge is specially designed for biogas upgrading.

The SEPURAN® Green membrane cartridge consists of several thousand hollow fibers manufactured from high-performance polymers and bundled in a stainless steel vessel. The ends are embedded in a resin. The membrane cartridge is contained in a closed housing unit.

The membrane system can now withstand a gas mixture under pressure.

Many membrane systems can be connected together in series as desired, depending on the application and the size of the system. The simple, easy-to-handle set-up takes up less space in the upgrading plant.

Thanks to the excellent selectivity of the membranes, the continuous separation process results in very high energy efficiency.



Cartridge housing

SEPURAN® Green cartridges are contained in specially developed housings. The housings are available in different variants to match local requirements.

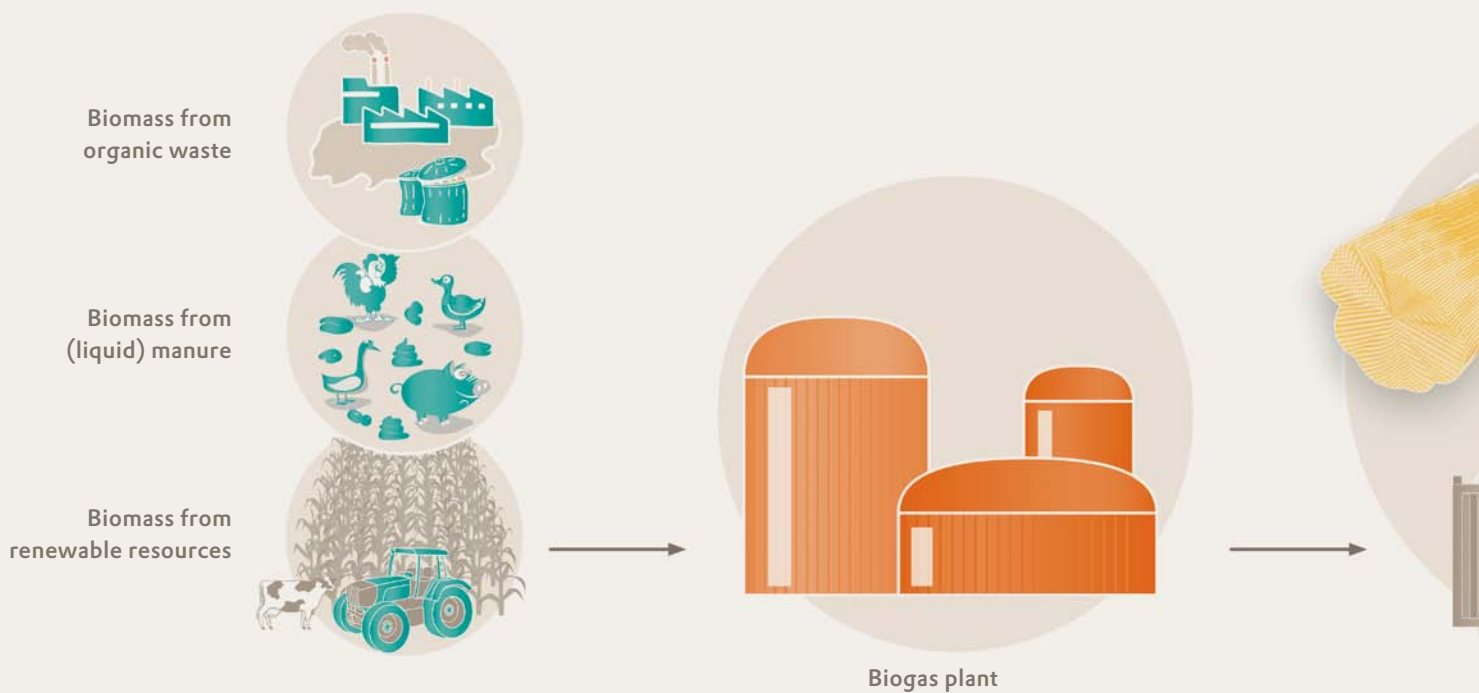
These stainless steel vessels for the SEPURAN® Green cartridges are manufactured by external partners, taking individual national requirements into consideration.

This offers plant engineering companies the advantage of being able to adapt the pressure housings to local pressure regulations. Housings for pressure up to 40 bara are available.

Benefits of the cartridge system

- Low weight
- Quick and economic membrane replacement
- Flexibility for housing designs
- Cost benefits in current expenses





SEPURAN® Green for biogas upgrading

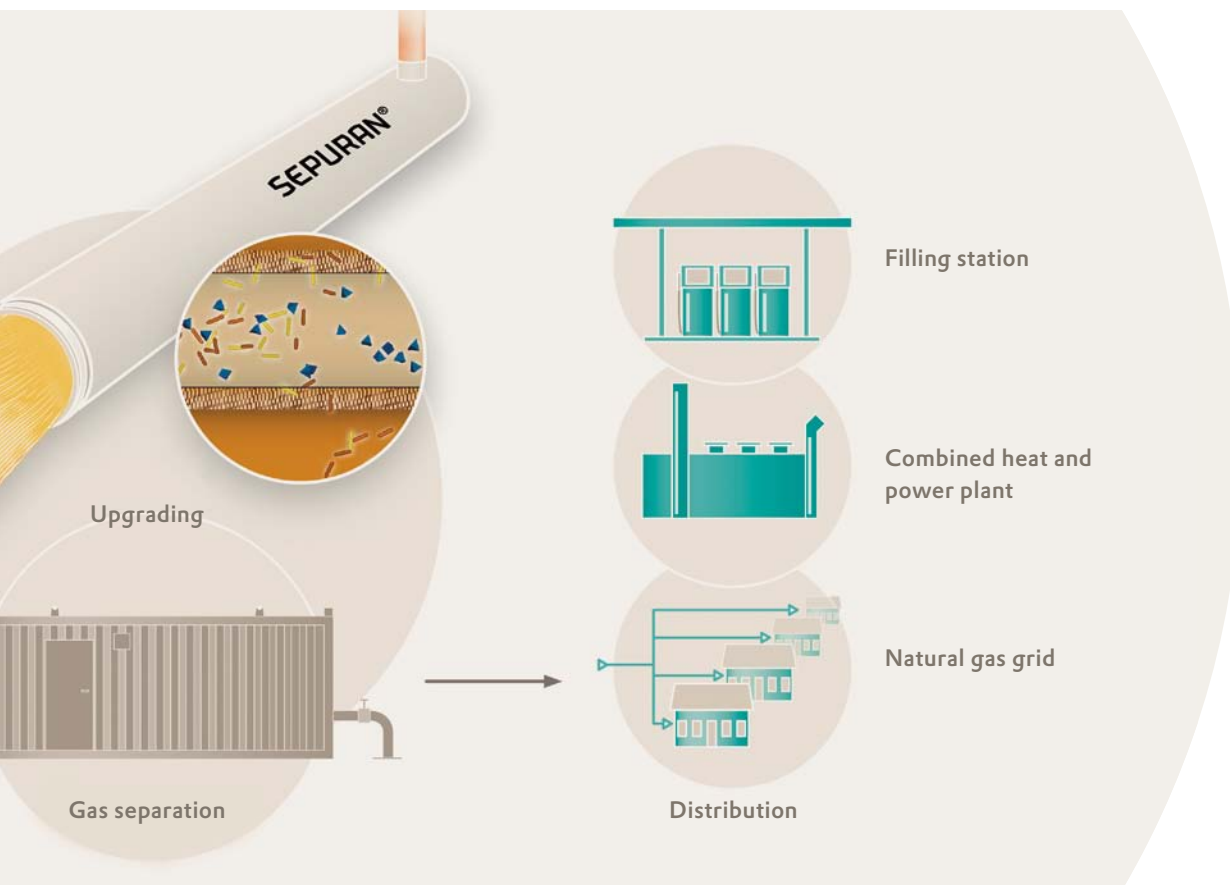
The SEPURAN® product family includes membrane systems for gas separation for various applications. Thanks to its high CO₂ over CH₄ selectivity, SEPURAN® Green is well suited for biogas upgrading.

Production of biogas

Biogas is formed by fermentation in which microorganisms anaerobically decompose biomass. Crude biogas contains 55–65% methane, 30–45% carbon dioxide, and trace gases such as hydrogen sulfide. After appropriate pretreatment and subsequent upgrading with SEPURAN® Green, the biomethane so produced is fed into the natural gas grid, providing consumers with eco-friendly, carbon-neutral gas.

Selectivity of SEPURAN® Green

Membrane-based upgrading of biogas exploits the differences in the permeabilities of gases through the membranes. SEPURAN® Green membranes have the highest selectivity and provide a superior technology for processing of crude biogas.



Technical background

The selectivity of the membranes is process-stable, even at higher pressures which are typical in the processing of crude biogas.

This is where Evonik's membranes distinguish themselves from other available membranes.

The innovative technology was first demonstrated and tested at an existing biogas plant in Neukirchen an der Vöckla, Austria and has since become established on the market.

Benefits

- Reduced operating costs
- Low investment
- Simple to operate
- Low space requirements and short installation times
- Can be used flexibly and in modular fashion
- No chemicals required
- No additional drying step

SEPURAN® Green in the biogas plant

Evonik has developed a biogas upgrading process that maximizes the performance of the membranes. By judicious combination of SEPURAN® Green membranes, methane of a purity higher than 99% can be obtained from the crude gas. The only equipment needed is a compressor.



Benefits

- Low methane slip (loss) of <1% during upgrading
- High methane yield of up to 99%, which means maximum added value for the operator
- Highest energy efficiency for upgrading (<0.2 kWel/Nm³ crude biogas, <0.4 kWel/Nm³ biomethane)
- No additional ancillary materials such as water or sorbents (amines, glycols) are required, so no emissions into the environment
- Easily regulated for changes in flow rate or composition
- Following the upgrading process with membranes, the biomethane is already dry and satisfies the dew-point requirement for feeding into the grid
- Easily scalable; can be used for small plants (10 Nm³/h) as well as large (>1000 Nm³/h)
- Starting and stopping of the plant is possible at short intervals, ensuring high flexibility; therefore ideally suited for operation of a biomethane filling station at the site
- Direct feeding (via a transmission pipeline) into the natural gas grid is possible without an additional compressor

The biogas leaves the biogas plant as a mixture of CO₂, methane, and the typical by-products. It is first desulfurized with active carbon, filtered, and pre-dried. The pre-cleaned gas is then drawn in with a compressor, compressed to 10–20 bar, and upgraded in several membrane stages to give biomethane and a CO₂-rich off-gas stream. The membrane-based upgrading process delivers a consistently high quality of biomethane that is up to 99% pure. Further, the off-gas is very clean and contains significantly less than 1% methane. Almost all of the methane is thus obtained in natural gas quality.

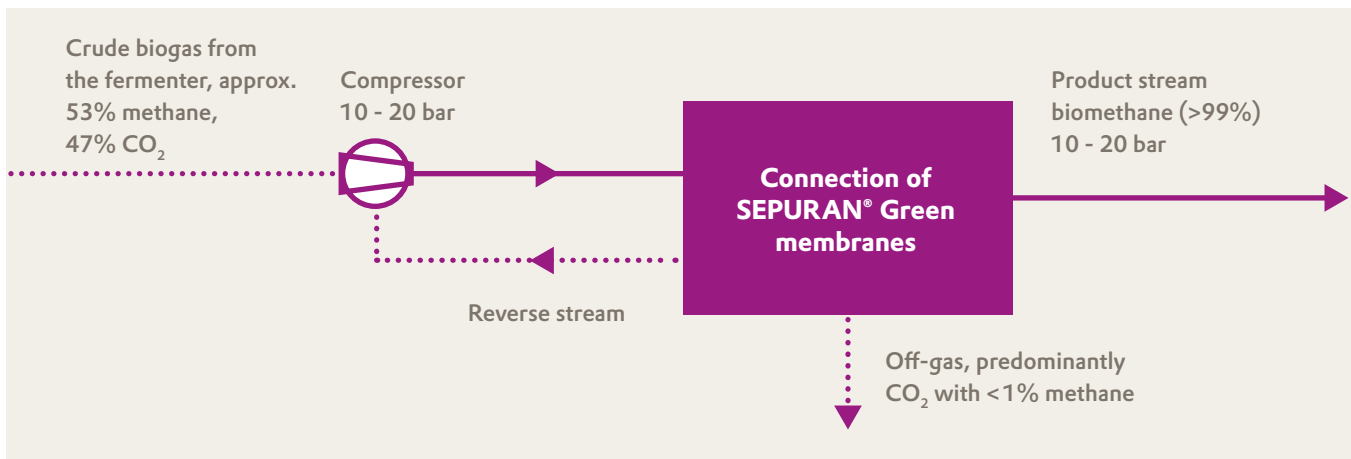
Evonik pilot plant

From 2011 to 2014 Evonik operated a pilot plant in Neukirchen an der Vöckla, Austria, to test the newly developed upgrading process with SEPURAN® Green membranes.

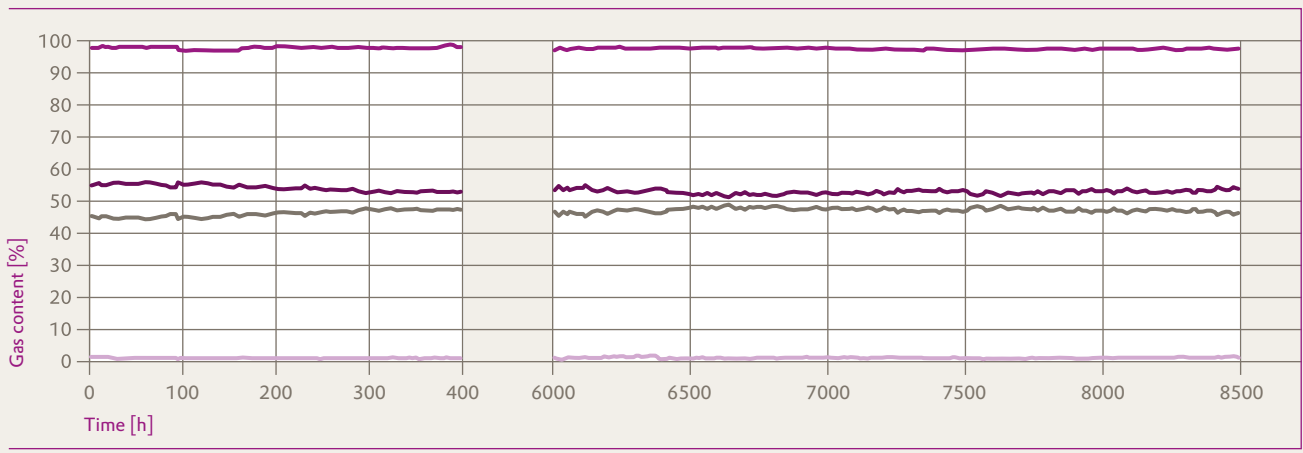
Our products and services

We offer SEPURAN® Green membrane technology and develop superior process solutions for your biogas separation requirements jointly with partners in plant engineering.

- SEPURAN® Green cartridges
- Process design for membrane-based biogas upgrading
- We work in conjunction with knowledgeable plant-engineering companies to offer system solutions on the market.



Gas content remains stable in the long term



— CH₄ off-gas — CH₄ product gas — CH₄ in crude gas — CO₂ in crude gas

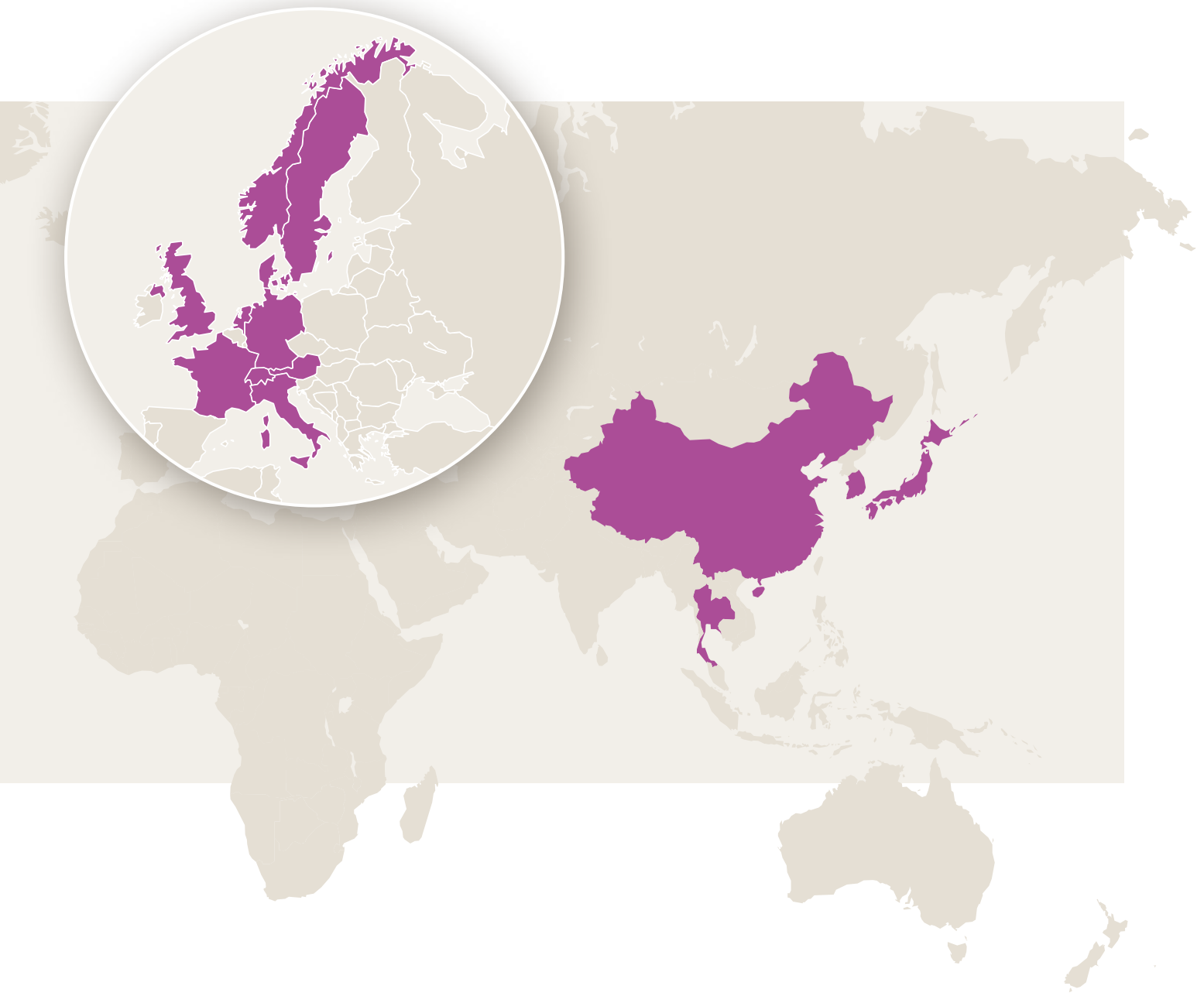


SEPURAN® Green – Our references worldwide

Biogas upgrading facilities* with SEPURAN® Green

Country	Quantity	Size [Nm³/h]			
		1-199	200-499	500-999	> 1000
Austria	3	●●	●		
China	2	●	●●●●	●	●●
Denmark	2			●	●
France	11	●●●	●●●●●●	●	
Germany	13	●	●●●	●●●●●●●●	●
Italy	1				●
Japan	1	●			
Korea	2	●			●
Netherlands	6	●●●●●		●	
Norway	1		●		
Sweden	2		●	●	
Switzerland	8	●●●●●●●	●●		
Thailand	2	●●			
United Kingdom	23		●	●●●●●●●	●●●●●●●●●

*Operating plants and plants under construction



Icknield Farm, Ipsden (Oxfordshire),
United Kingdom 350 Nm³/h

* registered trademark

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