Greenlane™

Biogas Upgrading Solutions
for all anaerobic digestion applications

Greenlane™ Cascade PSA AD product solutions deliver high quality RNG from biogas from any digester feedstock.

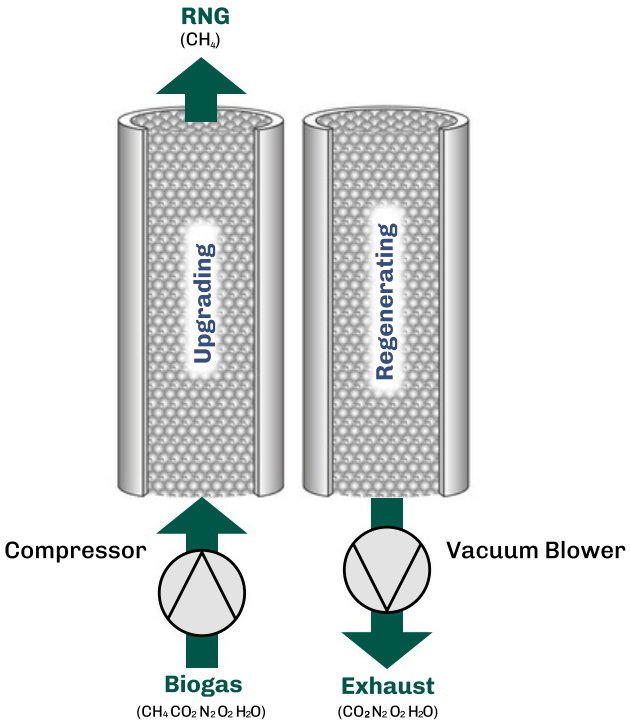
greenlanerenewables.com

Improving biogas management and value creation

Greenlane™ PSA Cascade AD products deliver end-to-end solutions especially for AD biogas applications.

Organic feedstocks are an excellent renewable energy source. Feedstocks such as manure, food waste, and wastewater biosolids generate biogas when subject to anaerobic conditions. Biogas generated from these sources need to be upgraded to create a clean, high-purity low carbon fuel: biomethane, or renewable natural gas (RNG).

Biogas upgrading systems utilizing pressure swing adsorption (PSA) technology cleanse the impurities in biogas by removing the carbon dioxide, nitrogen, oxygen, and water in a dependable and adjustable process that results in the creation of clean, high-purity, low-carbon fuel: biomethane or renewable natural gas.



Cascade PSA AD important benefits

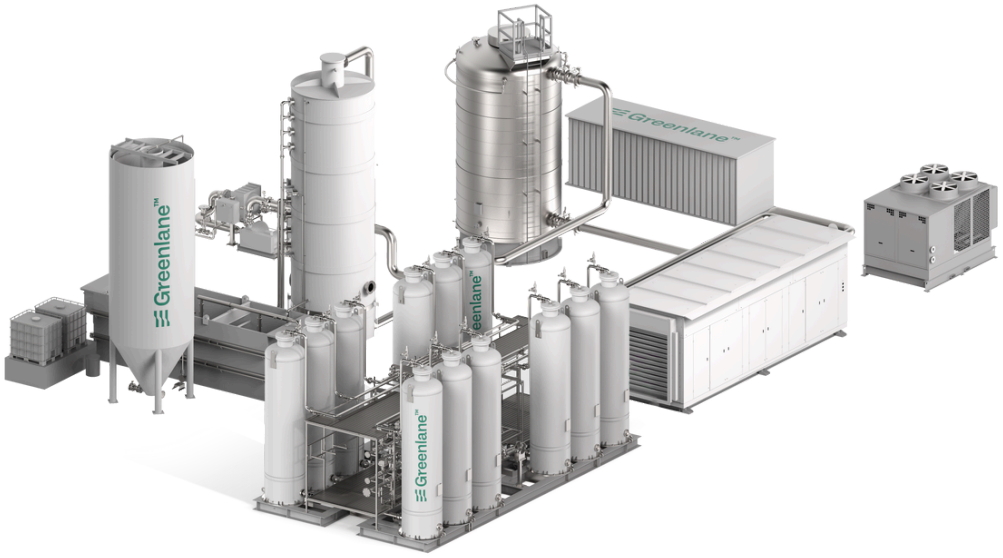
- **Efficiently reduces oxygen:** reduces nitrogen and oxygen, de-risking the process against biogas quality variation and increasing the safety margin against product gas specification.
- **Helps meet stringent pipeline quality requirements:** delivers end-to-end, standardized biogas upgrading solutions that meet most oxygen and nitrogen requirements without the need for additional equipment.

→ How Pressure Swing Adsorption Technology works

1. Raw Biogas is pretreated (removal of hydrogen sulfide, VOCs and Siloxanes), compressed, and conditioned;
2. The compressed and treated biogas is distributed through multiple vessels on the PSA skid via a single rotary valve;
3. As the gas moves through the beds, the majority of the carbon dioxide, nitrogen, oxygen, and moisture is adsorbed, resulting in RNG that meets pipeline specifications.
4. Fully saturated beds are depressurized and exchange gas with other beds in a series of steps to minimize the compression work and reduce pressure fluctuations in the product gas flow (RNG).
5. The beds are regenerated under vacuum and the carbon dioxide, nitrogen, and oxygen, and moisture are removed and exhausted.

Each PSA skid is constructed as a series of vessels each containing specialized adsorptive media. The carbon dioxide, nitrogen, oxygen, and water molecules adsorb in micropores of the media while the methane passes directly through the bed. This results in a continuous uninterrupted stream of high purity renewable natural gas (RNG).

The PSA regenerates by applying a vacuum to release all the adsorbed molecules and contaminants. Methane recovered during the depressurization process is recycled back to the inlet, ensuring the highest possible recovery rate. Product gas quality measurements provide the feedback control to further optimize methane recovery in a continuous and fully automated process.



Why PSA technology for biogas upgrading?

Pressure Swing Adsorption technology is often the best fit for challenging raw gas qualities, particularly when nitrogen and oxygen may be present.

Greenlane's Cascade PSA AD products:

- utilize a fast-cycle, multi-bed design with four depressurization steps leading to a lower operating cost and smoother outlet flow with minimized pressure fluctuation
- **offer the highest safety margin against the pipeline specification with the efficient removal of oxygen**
- can cycle quickly and responsively to changes in biogas flow rates and quality

The Cascade PSA AD advantage

- High methane recovery, depends on gas quality
- Lower OPEX than equivalent membrane separation
- Standardized plant design
- Adsorptive media lifetime of 10+ years
- Built for difficult upgrading applications
- Few moving parts and low maintenance needs
- High uptime
- Guaranteed RNG purity and methane recovery
- Cold Weather Packages available
- 24/7/365 on-call technical support

Cascade PSA AD installation

Cascade PSA AD models

Models	Flow (Nm^3/h)*
Small	≤ 1,000
Medium	1000 ≤ 1,250
Large	1250 ≤ 1,800

*minimum flow is 40% of max flow

Typical gas processing capability for RNG

Parameter	Raw Gas Quality	Product Gas Quality	Cascade MS
Methane (CH_4)	50-65 %	Meets Pipeline Quality Require-ments	Up to 98% guaranteed methane recovery
Carbon Dioxide (CO_2)	35-50 %		
Nitrogen (N_2)	0-1 %		
Oxygen (O_2)	0-0.2 %		
Hydrogen Sulfide (H_2S)	up to 3000*		

*contact us for higher H_2S levels

Greenlane™

Your trusted biogas upgrading partner

Greenlane Renewables is a leading global provider of integrated biogas upgrading systems, with more than 140 installations worldwide to date. We believe renewable natural gas is the most relevant renewable energy to support the decarbonization of commercial transportation and the natural gas grid.

Greenlane™ **Cascade suite of technologies** and products produce clean, low-carbon and carbon-negative RNG, creating value from organic waste at landfills and water recovery facilities, agricultural, food and organics. With water wash, pressure swing adsorption, membrane separation and proprietary desulfurization products available, Greenlane's commitment is to deliver exactly the right technology and level of service to meet our customers specific biogas upgrading needs and objectives.

Our services:

- 24/7 helpline
- Installation training, consulting, inspection
- Operator training and support
- Commissioning and performance testing
- Service and performance reporting
- Preventative and corrective maintenance
- Performance data analysis
- Options for service/maintenance contract
- Remote monitoring and management

For more information, visit greenlanerenewables.com

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#1 in global supplied capacity

140+ upgrading systems deployed

35+ years experience

19 countries supplied