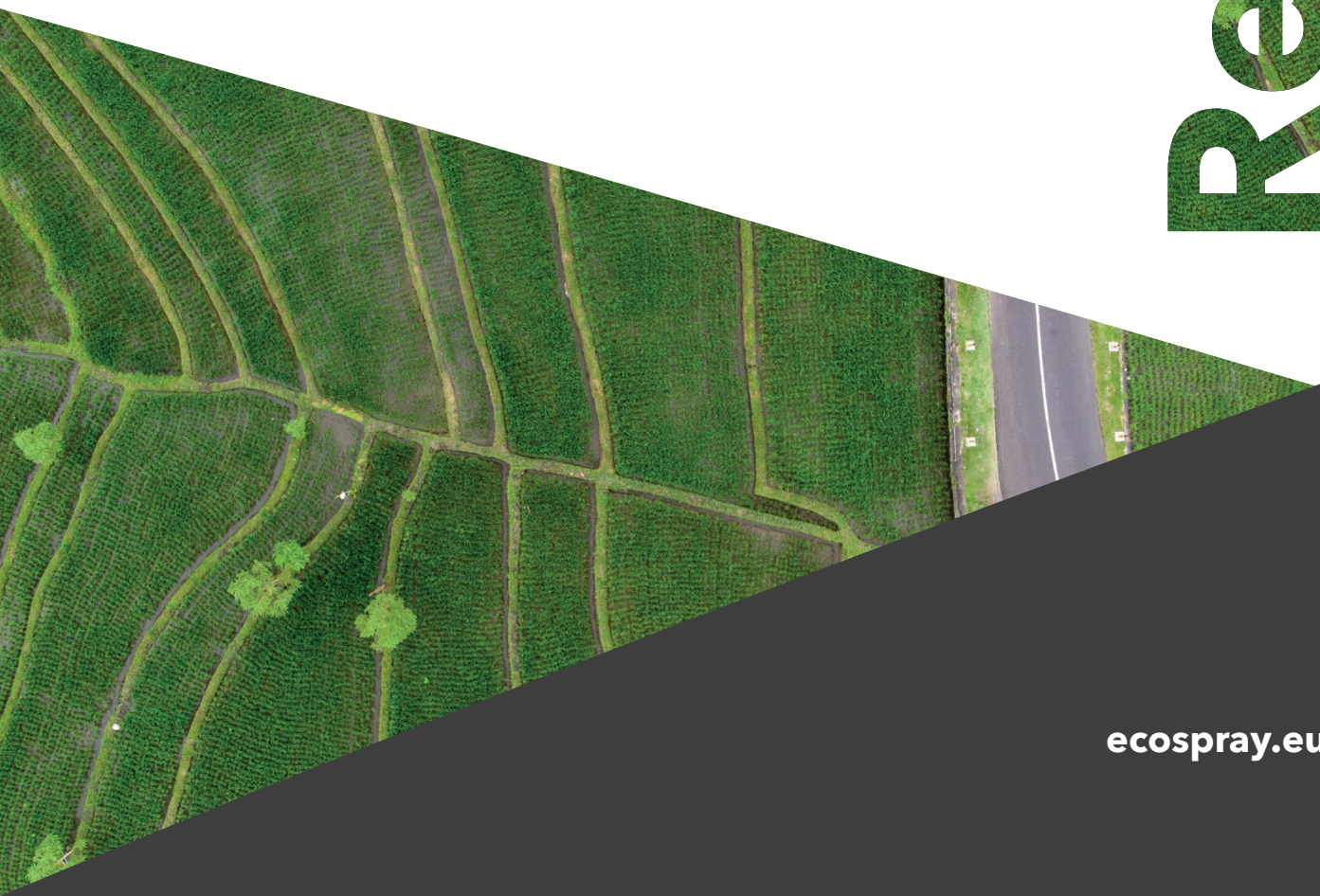
ECOSPRAY®
technologies for the planet

Renewables

Harvesting Value From Decarbonization

Unlock resources. Fuel Sustainability. Grow your business.



ecospray.eu

Overview

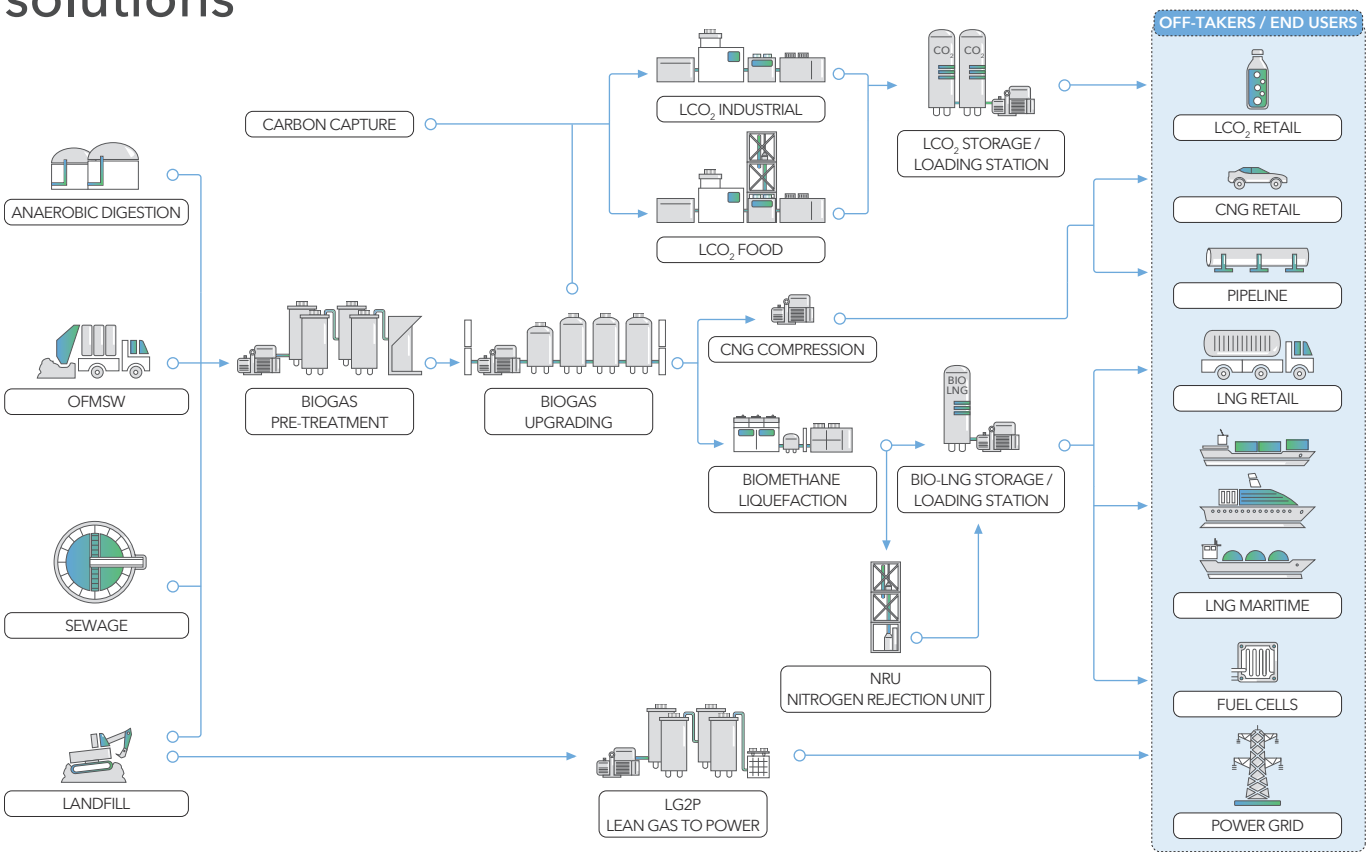
Applications

- Agriculture
- OFMSW
- Water treatment
- Landfill
- Bio carbon capture

Committed to accelerating the energy transition through innovative technologies, Ecospray provides solutions that enable the local production of **bioLNG** and **carbon-negative fuels**. Our compact, scalable systems for **biomethane** and **CO_2 liquefaction** transform organic, agricultural and landfill waste into clean energy, advancing decarbonisation through a circular economy approach.

Ecospray's solutions are designed to provide **low-carbon fuel technologies, carbon capture systems and waste-to-energy applications** which significantly reduce greenhouse gas emissions and environmental impact. Beyond sustainability, our technologies represent a strategic investment. By converting waste into valuable resources, reducing reliance on volatile energy markets and optimising operational efficiency, Ecospray helps businesses to secure **long-lasting profitability** and a **competitive advantage**.

Renewables solutions



RENEWABLES TECHNOLOGIES

Activities

Our 360° approach serves clients along the **entire value chain:**

- Research & Development
- Engineering
- Production
- Installation supervision & commissioning
- After sales support
- Training & management

Service & Training

With more than 20 plants already delivered Ecospray's dedicated **after-sales services** ensure consistent **optimized performances** and plant **reliability** levering remote supervision tecnologies and industry best practices honed from our extensive experience both large marine installations and diverse renewable energy plants.

Our globally recognized **Training Center** provides **tailored courses for professionals**, both in-person as well as online, ensuring operators are properly skilled to maintain systems effectively.
Ecospray training courses help to **maximize efficiency**, to **reduce risks**, and to stay ahead of regulatory requirements.

Biogas Pre-treatment & Upgrading

Description

Inlet biogas stream from:

- Agriculture
- OFMSW
- Water treatment
- Landfill
- Any organic fermentation

Pre-treatment

Designed for both biogas and natural gas, our system **removes H_2S, VOCs, HCl, NH_3 and more** with high-performance **activated carbons**. It operates continuously, meeting the toughest regulations while **drying gas to a dew point of -30 °C**. From waste and agricultural sources to landfill and fossil gas, it delivers safe, efficient pre-treatment with **minimal maintenance**.

Biogas upgrading

Ecospray provides **complete upgrading solutions** when required, integrating the most widely used VPSA and membrane technologies into a seamless process, combined with our core expertise in **biomethane and CO_2 liquefaction**.

- **VPSA Technology**

  VPSA (Vacuum Pressure Swing Adsorption) efficiently removes CO_2 and other impurities from biogas through alternating pressurization and vacuum cycles, using synthetic zeolites as the adsorption medium. This proven method delivers **low energy consumption** (<0,2kWh/Nm^3_{biogas}), reliable performance across a wide range of plant sizes, and excellent results even **with challenging gas compositions and pollutants**.

- **Membrane Technology**

  High-performance polymer membranes selectively separate CO_2 from biogas, enabling efficient upgrading and carbon capture with **high methane recovery** rates (>99%). Their modular design ensures easy **scalability, minimal maintenance**, and a sustainable approach to gas processing.

Technical Information

Process

The pre-treatment stage is designed to stop large contaminants and capture pollutants with active carbons and condensing water with proper chiller and demister.
The VPSA system uses three molecular sieve reactors, sized to the biogas composition, for efficient CO_2 removal. A guard filter traps any zeolite particles, while vacuum pumps efficiently strips the captured CO_2. An additional reactor recovers methane slip from the off-gas, which is recirculated to the pre-treatment stage for maximum efficiency.
The polymer-based hollow-fiber membranes use selective permeation to separate CO_2 from biogas – compressed by a dedicated screw compressor – with, energy-efficient steps, maintaining methane purity above 99 % with minimal energy use and no chemicals. The system can be configured with two or three membrane stages to achieve the desired methane recovery rate.

Features

- **Compact & modular design** – skid with standard sizes (40 ft) with a flexible design to adapt to the user's available space, easy to transport, install and relocate.
- **Versatile** – designed to process diverse sources – from organic waste and agricultural facilities to wastewater sludge, landfill gas and fossil gas without performance loss.
- **Process engineering expertise** – deep know-how in designing seamless interfaces between upgrading systems and downstream biomethane/CO_2 liquefaction units for maximum efficiency managing the produced offgases and boil off.
- **Custom system design** – tailor-made configurations of VPSA or membrane solutions to match specific gas compositions, flow rates, and end-product quality requirements.
- **Turnkey project delivery** – from design and engineering to commissioning and support, ensuring smooth integration and reliable, long-term operation and single interface.
- **Unmanned** – a remote control of process variables is provided, including web-based access and proper database storage.

Biomethane Liquefaction - bioLNG

Description

Inlet biomethane stream from:

- Membranes
- PSA/VPSA
- Amine/Potassium Carbonate
- Water scrubber
- Any upgrading system

Ecospray provides **on-site biogas liquefaction solutions**, enabling the liquefaction of biomethane for the creation of a virtual pipelines for the widespread distribution of LNG. The liquefaction system is a fully scalable solution built around an in-house designed **cryogenic chiller based on reverse Brayton closed-cycle technology**. The system can be configured to match desired LNG demand characteristics for **bunkering, power generation or transportation.**

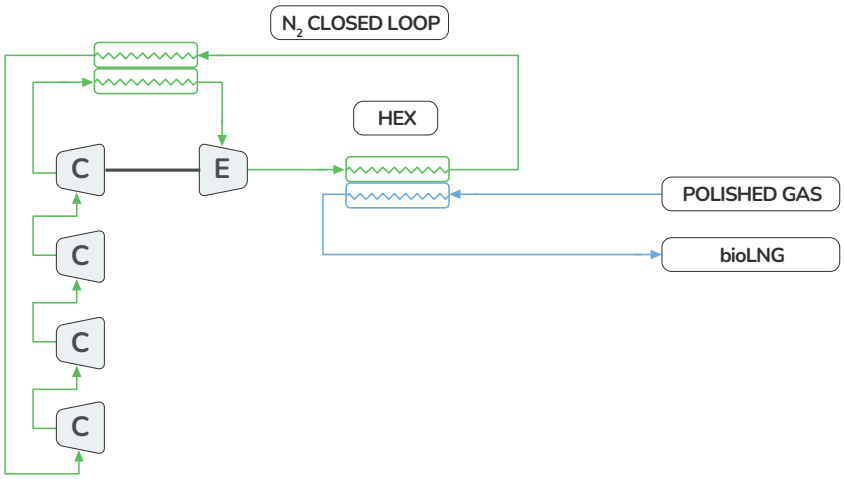
Each module has the capacity to produce:

- 9.5 tpd of LNG @ -160°C/-256°F processing 550 Nm^3/h or 0.5 MMSCFD;
- 12.0 tpd of LNG @ -150°C/-238°F processing 620 Nm^3/h or 0.6 MMSCFD.

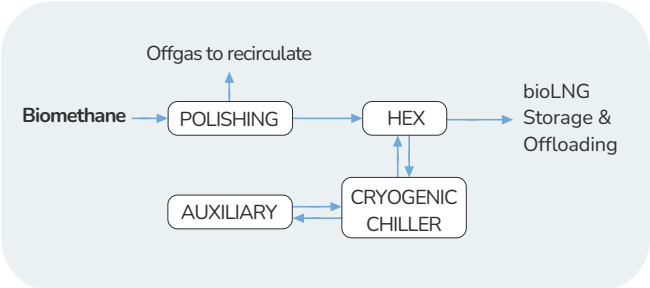
Process

The liquefaction system fully integrates all units (polishing, heat exchangers and cryogenic chiller) which are consistent with the specific process and can be configured for various types of inlet gas.

Biomethane liquefaction process



Flow diagram



Polishing

The polishing unit purifies biomethane to meet strict liquefaction standards—below 50 ppmv CO_2 and 1 ppmv H_2O. It uses three fixed-bed adsorption columns filled with selective synthetic zeolites (13X and 3A). Operated in a staggered cycle (adsorption, regeneration, standby), this setup ensures continuous polishing and prevents off-spec gas breakthrough.

Cryogenic chiller

The cryogenic chiller cools the inlet gas using a **reverse Brayton cycle with self-generated nitrogen** as the refrigerant in a closed loop. This process—compressing, cooling, and expanding the nitrogen—lowers its temperature below the inlet gas liquefaction point. This enables the **production of bio-LNG** at the required commercial quality for **transport, bunkering, and power generation**. The unit is designed to automatically compensate any nitrogen small leaks.

Features

- **Compact & modular design** – skid/container (40-45 ft) with a flexible design to adapt to the user's available space, easy to transport, install and relocate.
- **Reliable** – separating the cooling media (nitrogen) and inlet feed gas ensures the maximum reliability by avoiding any contamination, corrosion and wear.
- **Efficient** – moderate energy consumption for liquefaction, with operating costs mainly due to power comsumption.
- **Flexible** – possible to turndown the production of LNG to 40% of the maximum capacity and at desired LNG commercial specs (pressure and temperature).
- **Safe** – operational with self-generated nitrogen cooling media to avoid explosion or jet fire dangers with a zero GWP (Global Warming Potential).
- **Complete** – containers come complete with insulation, lighting, air conditioning, doors and ventilation to facilitate operating activities.
- **Unmanned** – a remote control of process variables is provided, including web-based access and proper database storage, allowing remote parameters control and proper maintenance scheduling. Plant data, including alarms, are available via OPC from the operator interface system (HMI).

CO_2 Liquefaction - LCO_2

Description

Inlet stream from CO_2:

- biogas upgrading systems
- DOC (Direct Ocean Capture)
- DAC (Direct Air Capture)

The CO_2 liquefaction system is part of the solutions Ecospray provides to the customers **to support** their **decarbonization** journey. The system can be installed stand-alone or coupled with a carbon capture system, both for marine and land-based applications. From a carbon capture system, the **inlet CO_2** rich stream is **collected, "cleaned", dried and liquefied for industrial** (99,5%), **food or permanent sequestretion applications** (99,99%).

The liquefied CO_2 is then sent to the tank, where it remains until it is collected by the user according to the procedures set out under the international regulations. This process creates a **virtual pipeline**, connecting CO_2, emission sources and utilisation hubs **without** the need for **permanent physical infrastructure**.

Module production capacity:

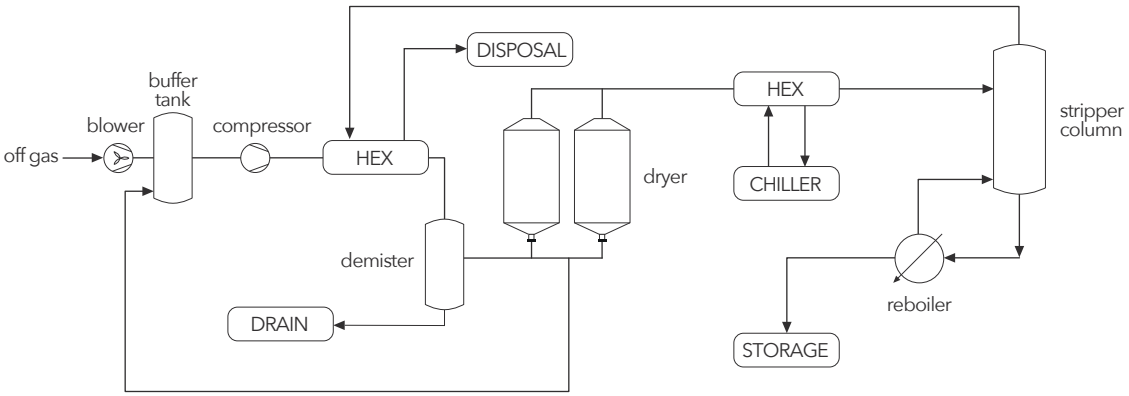
- Pilot (upon request) from a minimum modular size of 1 tpd;
- Industrial scale application: up to 72 tpd module size.

Features

- **Compact & modular design** – skid/container (40-45 ft, horizontal or vertical footprint) with a flexible design to adapt to the user's available space, easy to transport, install and relocate.
- **Efficient** – moderate energy consumption for liquefaction, with operating costs mainly due to power comsumption.
- **Flexible** – possibility of partializing the production of LCO_2 up to 50% of the maximum capacity and at desired LCO_2 commercial specs (grade, pressure and temperature).
- **Safe** – operational with no dangerous or unsustainable cooling media to avoid explosion or jet fire dangers. It can be used in classified or safe areas.
- **Complete** – containers come complete with insulation, lighting, air conditioning, doors and ventilation to facilitate operating activities.
- **Unmanned** – a remote control of process variables is provided, including web based access and proper database storage, allowing remote parameters control and proper maintenance scheduling. Plant data, including alarms, are available via OPC from the operator interface system (HMI).

Process

The process consists in an initial **purification** of the raw inlet gas to clean micro pollutants, followed by a **drying unit to remove the H_2O before the compression and cooling stage reaching the liquid phase.**
Furthermore, the liquifided CO_2 - still industrial grade - is then sent in the **stripper tower to reach food or permanent sequestration grade**, collected at the bottom of the column.



Lean Gas To Power

Description

Lean gas Inlet stream from:

- Landfill
- Coal mine
- Process off-gas (i.e. upgrading)
- Boil off
- Off-spec gas
- Any source with +1,5% methane

Across landfills, wastewater plants, and industrial sites, vast amounts of **low-methane gas** are usually flared or wasted, contributing little value while releasing greenhouse emissions. Ecospray's LG2P (Lean Gas to Power) system is engineered to **convert** these **ultra-lean gas streams** - down to 1.5% CH_4 - **into reliable electrical and thermal energy**. By turning an environmental liability into a valuable resource, LG2P delivers both sustainability and efficiency in a compact, **containerized solution**.

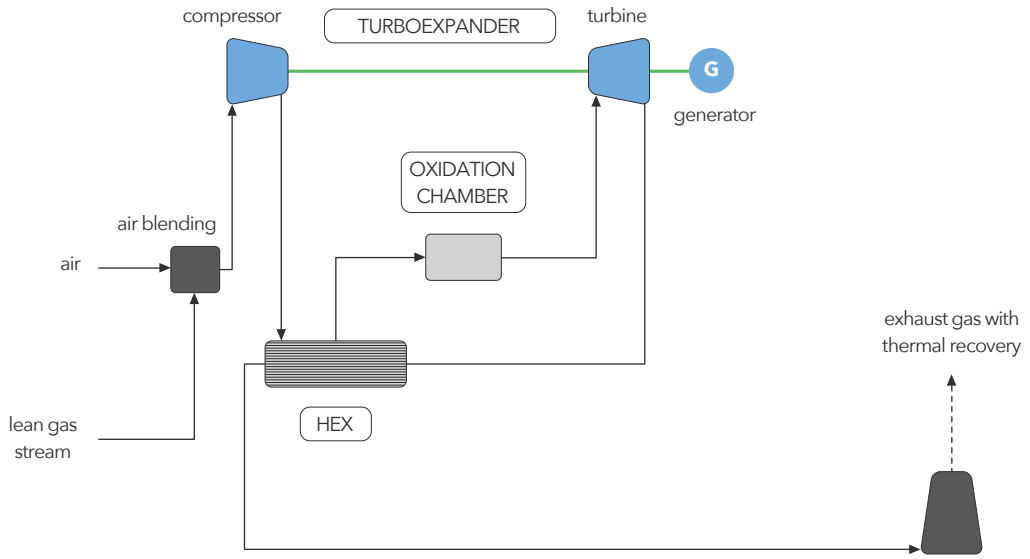
An oxidation chamber ensures minimal methane slip and zero harmful by-products, making it ideal for low methane concentration gas flows or methane slip reduction in upgrading systems.

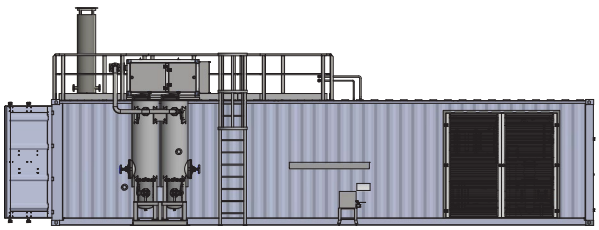
Features

- **Compact & modular design** – skid/container (40-45 ft) with a flexible design to adapt to the user's available space, easy to transport, install and relocate reducing footprint compared to biofilters, which are significantly larger than our containerized solution.
- **Eliminates greenhouse gas emissions**, achieving CH_4 levels below 0.2 % after oxidation and prevents harmful combustion by-products (NOx, SOx) through low-temperature oxidation.
- **Increases landfill value** by recovering the maximum possible gas from low-methane sites through efficient gas extraction supporting s landfill sustainability, contributing to a true decarbonization process.
- **Converts waste into a valuable resource,** eliminating disposal costs.
- **Unmanned** – a remote control of process variables is provided, including web based access and proper database storage, allowing remote parameters control and proper maintenance scheduling. Plant data, including alarms, are available via OPC from the operator interface system (HMI).

Process

The LG2P system **utilize any low-calorific gas with a CH_4 content down to 1.5%** (i.e. only 50 Sm³/h of methane diluted in approximately 4,000 Sm³/h of gas flow) generating gross 130 kWe while recovering about 300 kWt of thermal energy from gas at +200 °C. The waste gas is processed to abate its GWP of at least one order of magnitude through an oxidation chamber with an MBTM above the industry average.





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