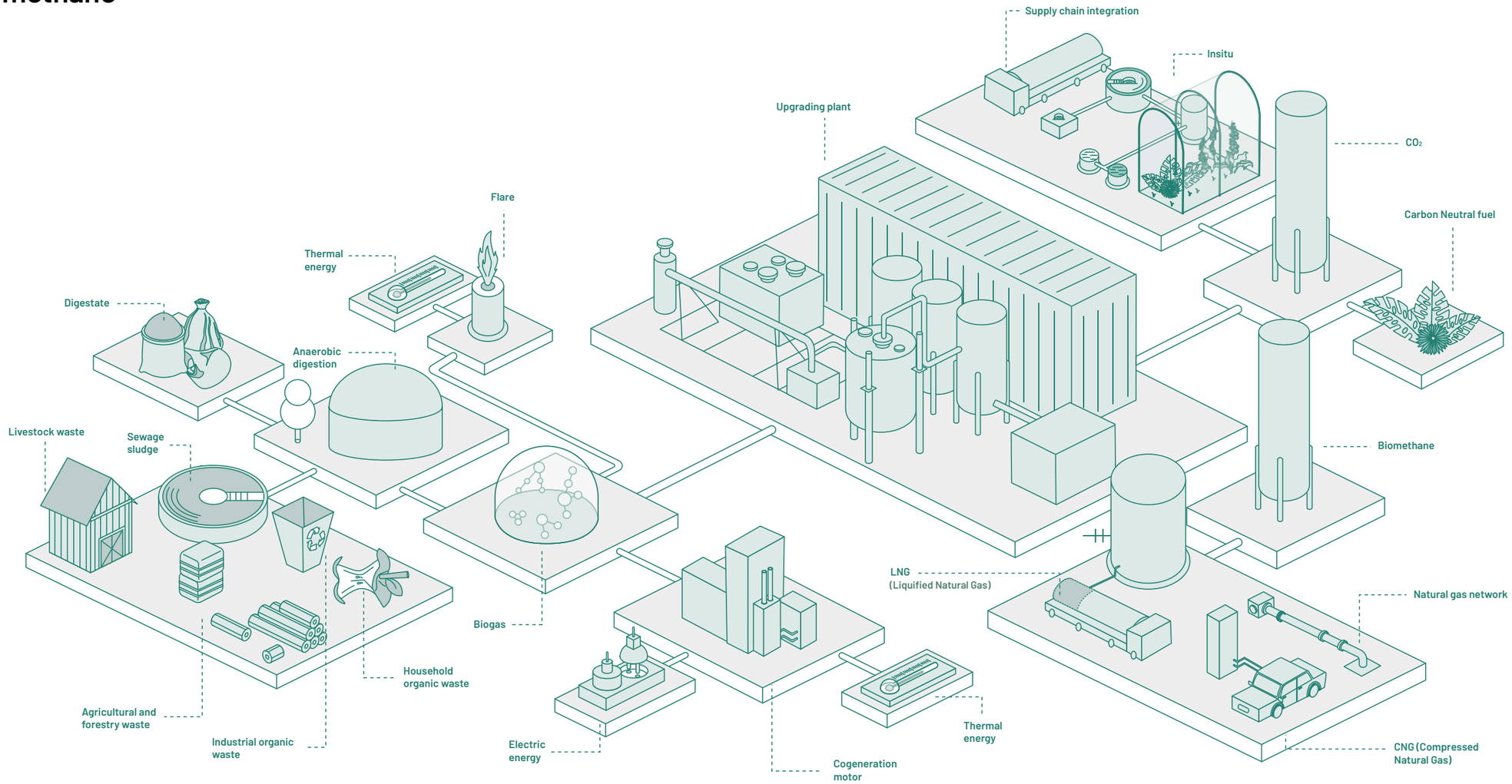
NIPPON GASES

Biomethane, Bio-LNG, Bio-CO_2 and Bio-H_2

Where industry meets renewable gases

From biogas to biomethane



Why biomethane?

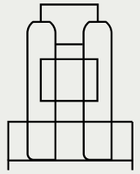
The production of biomethane from biogas enables progress towards a circular economy and respect for the environment.

- Renewable energy generation.
- Decarbonization, reducing greenhouse gas emissions
- Economic assessment of waste.
- Green energy that can be stored and easily distributed.
- Promotes sustainable mobility.
- Fosters industrial development in rural areas.
- CO_2 Recovery for reuse in industrial applications.

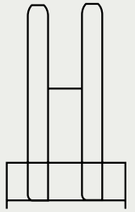
Adapted technology for each case:

We study and propose the most efficient technology according to the context:

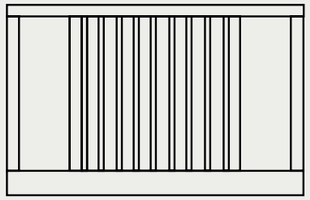
- Adsorption (VPSA)
- Chemical absorption – Membranes
- Water washing (PWS)



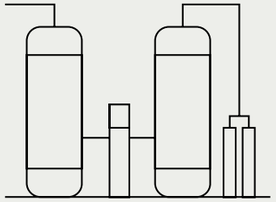
VPSA
Vacuum Pressure Swing Adsorption
Biomethane can be separated from CO_2, O_2 and N_2 with adsorbent materials and pressure variations.



Chemical Absorption
Certain chemical compounds, such as amines or alkaline salts, absorb CO_2, H_2S y VOCs, producing biomethane.



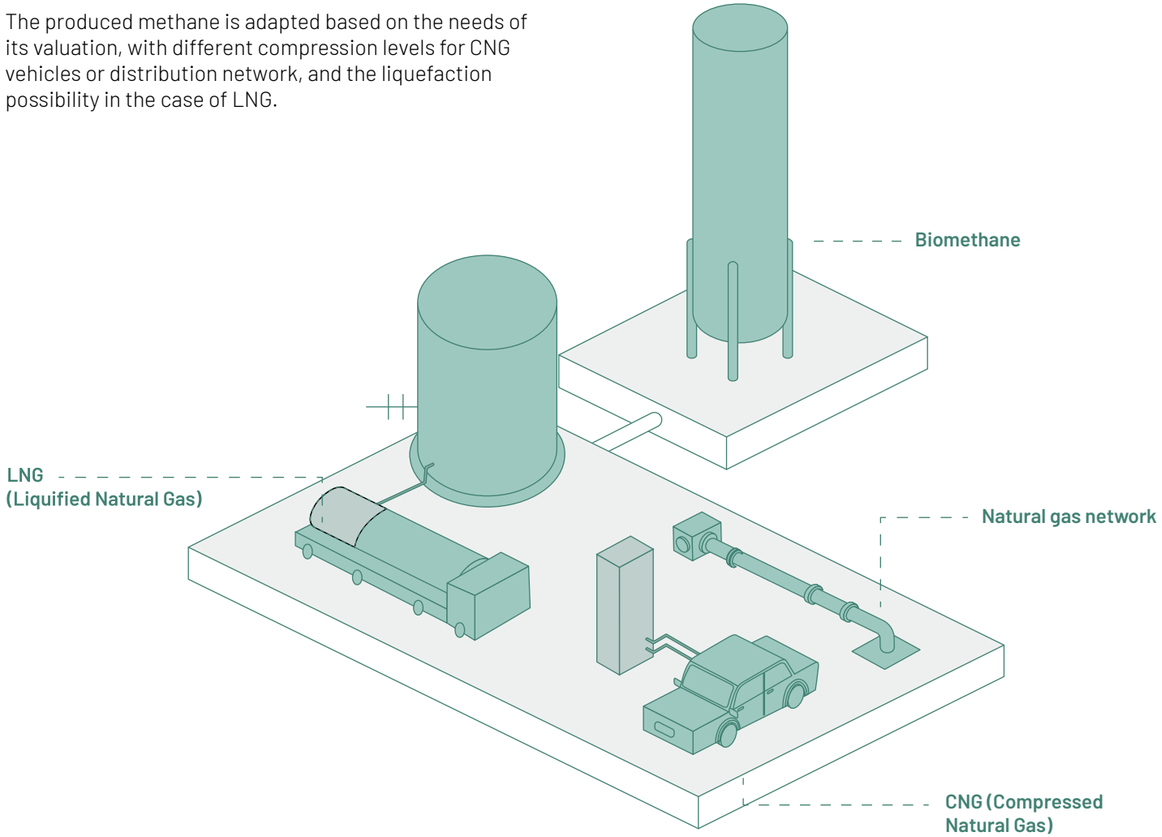
Membranes
Biomethane is obtained by passing the pressurized biogas through selective membranes, separating it from CO_2.



PWS
Pressure Water Scrubbing
Methane and CO_2 are separated due to the difference in water solubility of both compounds.

Biomethane valuation

The produced methane is adapted based on the needs of its valuation, with different compression levels for CNG vehicles or distribution network, and the liquefaction possibility in the case of LNG.



What we offer

Tailored solutions, adapted to customer's needs and for all gas separation technologies and their implementation.

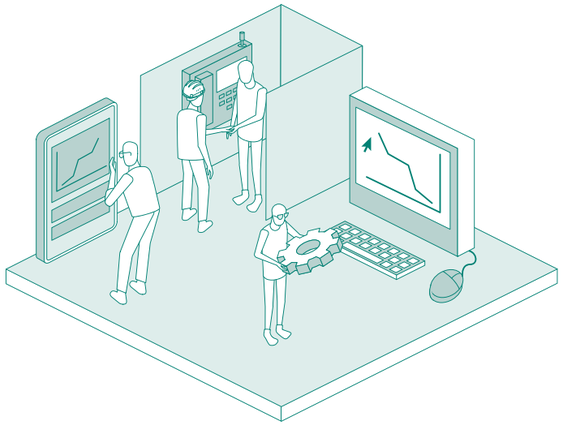
Flexible collaboration models tailored to your needs
- Sell of Equipment
- Renting (we take care of it!)
- We Build Own and Operate
- Molecules off-taking
- CCS and CCU services

Different types of biogas and biomethane valorization
- Injection to grid
- Liquified Natural Gas (LNG)
- Compressed Natural Gas (CNG)
- BioCO_2 and BioH_2 from the biogas when valuable

On-site facilities with remote surveillance and technical assistance

Customer service over the life of the installation

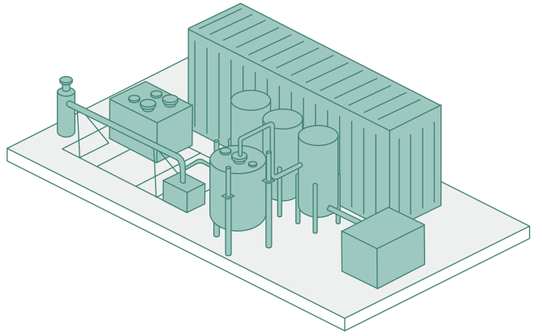
Other services
- Business case analysis support
- H2S content control in the biogas with the best solution (Oxygen or PSA)
- Transform digestate into a valuable product (ammonia NH_3 content management).
- Gas carrier mixture for the gas analysis and instruments calibration"



Full Hybrid Upgrading System

The Full Hybrid system proposed by Nippon Gases is based on the optimisation of the upgrading process thanks to the combination of a water scrubbing and a double purification stage on membranes.

This solution avoids further pre- treatment, reducing operating costs minimising or eliminating the use of activated carbon and reducing the specific energy consumption for the production of Biomethane, compared to traditional systems three-stage membranes.



How does it work?
The first stage of treatment takes place through washing in water, without the addition of any chemical agent and in a closed cycle. Subsequently, the biogas, now completely pre-treated and enriched in CH_4, is sent to a separation section in diffusion membranes. Here the CO_2 permeates faster than methane, allowing to obtain a Biomethane current in network specification.

Strong

- Plant uptime >8,500 hours/year.
- Optimised compression and filtering system to ensure lower downtime.
- Combines the robustness of water scrubbing tower with the simplicity and compactness of H2S- resistant membranes.
- Biogas treatment via pressure washing tower/scrubber.
- Up to 90% reduction in activated carbon consumption for H2S removal and VOC reduction.
- Ammonia abatement, without additional equipment.
- Automations for process control with sophisticated algorithms to ensure maximum production of Biomethane.
- Exclusive use of high-quality stainless steel components and instruments.

Safe

- Minimised methane slip.
- Continuous monitoring and control of pressure, temperature, humidity, maximum operational and production yield (>97% of the time).
- No formation of oxide dust inside the pipes.
- Redundant systems.

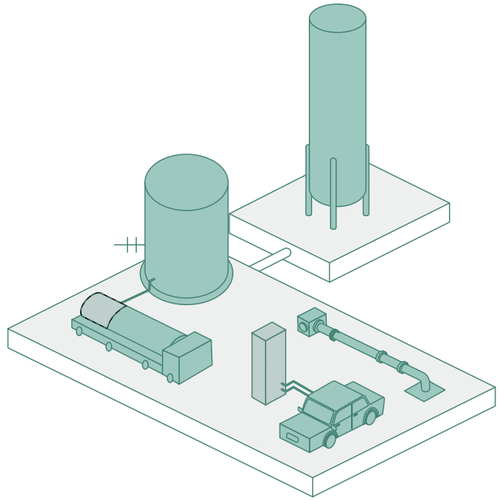
Sustainable

- Low energy consumption -15% compared to conventional three-stage membrane systems.
- No chemical additives required.
- Minimal water consumption (closed cycle scrubber).
- Methane recovery >99.5%.
- Flexible system that can be adapted to the continuous operational changes of the biodigester.
- Possibility of adding production modules in the event of major changes in the biogas flow.
- Easily modifiable layout.

Biomethane Liquefaction System - BioLNG

The Biomethane Liquefaction System proposed by Nippon Gases exploits the unique potential of the cryocondenser Stirling such as reliability, compactness and modularity. LNG is obtained, after appropriate purification and dehydration treatments, by subjecting the biomethane to successive phases of cooling and condensation.

In particular, the technology used for the production of 1-30 tonnes/day of LNG, is more competitive due to its greater energy efficiency compared to traditional processes of larger size (Linde, Claude, Joule- Thompson, Brayton).



How does it work?
The liquefaction process involves alternately the compression and expansion of a fixed quantity of an almost perfect gas (also known as ideal gas).

As it is a closed cycle, the working gas of the cryogenerator (He in a gaseous state) never comes into contact with the substance (gas or liquid) that is cooled in the main process. This also eliminates contamination of the working gas, resulting in greater operational safety.

Strong

- **High quality Liquefied Natural Gas, the system can reach -155°C, also allowing long-range transport and sales abroad.**
- Plant uptime >8,500 hours/year.
- Manufactured with high-quality stainless steel components and tools. • Plug and Play and modular (modules from 1 to 30 tpd).
- Intrinsically redundant design for multiple machines.

Safe

- More efficient removal of non-condensable gases (N_2, O_2, H_2, etc.).
- No process fluid in contact with mechanical parts (heat exchanger).
- Equipment approved by BV, ABS and USCG.

Sustainable

- High energy efficiency compared to other cryogenic processes.
- Environmentally friendly system, does not contribute to the greenhouse effect and does not discharge harmful or toxic gases.
- Flexible system, adaptable to daily operational changes.
- Possibility of adding production modules in case of major changes in the biogas flow.
- Easily modifiable layout.

Nippon Gases plants are designed on customers' specific needs of and built to produce continuously and at maximum output.

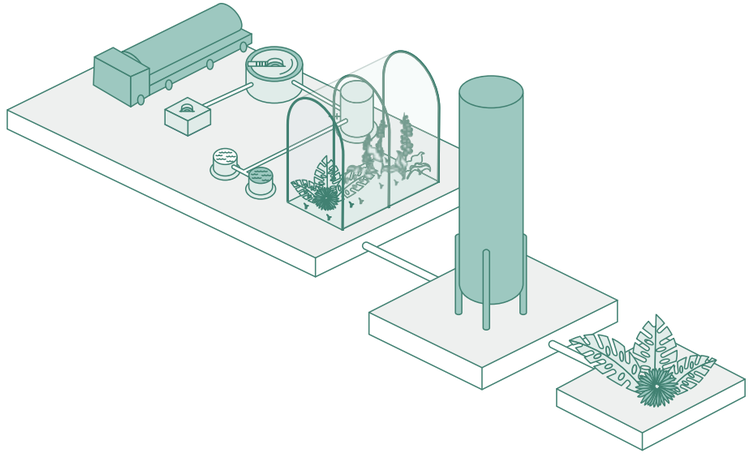
CO_2 recovery system

The plant proposed by Nippon Gases allows the recovery of BioCO_2 from the vent of the Biogas Upgrading plant which is a stream with a high concentration of CO_2 and contains a limited amount of methane and other impurities.

By installing a recovery plant CO_2 downstream of the Biogas Upgrading plant it is possible to increase the amount of Biomethane recovered from the Biogas by increasing the yield of the Upgrading plant (up to 99.9%).

Recovered biogenic CO_2 can be used in industry (technical grade) or achieve purities compatible with the requirements of the Food & Beverage sector.

How does it work?
The stream to be treated is compressed to a pressure of 18 barg, dried in a self-healing double tank system, and liquefied at a temperature of -25°C.



Strong

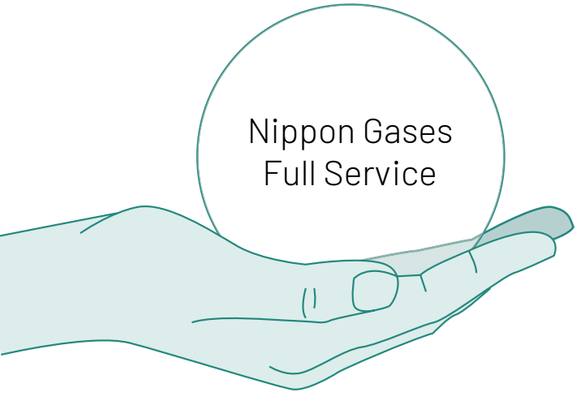
- The biogenic CO_2 obtained can achieve purities compatible with the specifications required in Food & Beverage.
- Guaranteed plant uptime 8,500 h/year.
- Fully automated.
- Plug & Play execution on single skid (for flow rates up to 1,000 kg/h of CO_2) for quick installation.

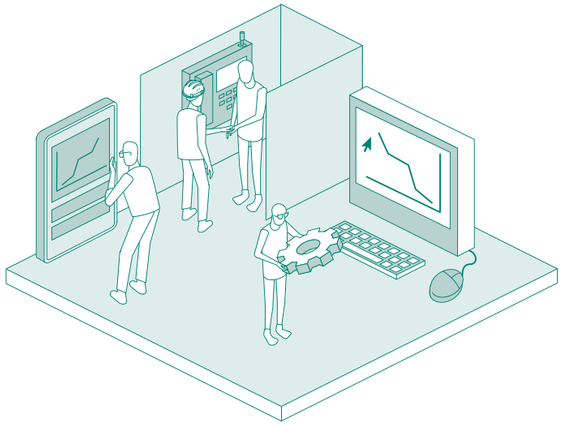
Safe

- Limited atmospheric emissions.
- High CO_2 recovery efficiency.
- Optimised to customer requirements.

Sustainable

- Direct CO_2 production can lead to a negative Carbon Foot Print and a reduction of the CI (Carbon Intensity Score).
- Environmentally friendly system, does not contribute to the emission of harmful or toxic gases.
- Flexible system and simplified turn down.
- The refrigerant used in the refrigeration circuit is low GWP.





Simple functioning

- Quick and fully automated startup sequence (just press “start”).
- Operation is automatic, no supervision is needed.
- Remote monitoring, diagnostics, and control (available 24/24h, 7/7 days).
- Plant optimization (production, energy consumption, etc.).
- Remote support and data assistance for routine checklists.

Onsite services

- Process experts support.
- Scheduled preventive maintenance activities (Labour and spare parts).
- Extraordinary maintenance.
- Supply and management of critical spare parts.

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