# AGRIPURE®

The system for biogas upgrading.

## PLANTS
Efficient. Innovative. Sustainable.

## COMPONENTS
Proven. Robust. Reliable.

## UTILISATION
CHP. Biomethane. Digestate.

## SERVICES
Support. Advice. Expertise.


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aK agriPure® INTL


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agriKomp GmbH: Certified acc. to ISO 9001

# Biomethane
# The sustainable alternative

AGRIPURE®

## RENEWABLE FUEL WITH POSITIVE CHARACTERISTICS

Biogas is produced naturally through the anaerobic digestion of organic waste and residues.

The biogas produced is a mixture of approx. 50 - 75 % methane, 25 - 50 % carbon dioxide plus trace gases such as hydrogen sulphide, oxygen, nitrogen, ammonia, and hydrogen. Biogas can be used to generate electricity and heat in CHP units but often the full energy potential is not utilised. By upgrading biogas to biomethane, this full energy potential can be realised along with many other positive characteristics and possible applications.

## WHAT IS BIOMETHANE?

Commercially available natural gas contains a high percentage of methane with smaller amounts of nitrogen and carbon dioxide. Its calorific or energy value can vary depending on where it is sourced across the world. The upgrading of biogas produces biomethane, which can be fed into the natural gas grid as a natural gas substitute and used in the same way.

## FROM BIOGAS TO BIOMETHANE

The biogas produced, also called raw gas, is first subjected to pre-treatment which removes impurities from the biogas input before it enters the compressor and separation membranes. It includes gas drying, activated carbon filter and pre-compression.

In the subsequent upgrading process, the $CO_2$ and other gases contained in the raw biogas are separated using membrane technology. The upgraded gas contains up to 99% methane and is now called biomethane or bio natural gas. The other separated gases such as $CO_2$ and $H_2$ can be utilised for further applications.

## CHEMICALLY EQUIVALENT TO NATURAL GAS

In general, after biogas upgrading, biomethane can be used wherever natural gas is used. Both variants are chemically equivalent and differ only in their fossil or biogenic origin. Before feeding it into the natural gas grid, it may be necessary, in some jurisdictions, to adjust the calorific value (e.g. by adding propane) and to odorise the biomethane for safety reasons, because methane is ordourless.

## STOREABLE & TRANSPORTABLE

Biomethane can be fed into the natural gas grid and be transported through it. This makes it possible to use it far away from the place of production. National gas grids are also a significant and cost effective storage resource where biomethane can be made readily available to the end user. With this positive contribution to demand-responsive energy production, biomethane has a unique advantage compared with many other forms of renewable energy.

## A LOW CARBON FUEL, REDUCING NEED FOR IMORTED GAS

The biomethane fed into the grid replaces fossil natural gas and benefits from a balanced $CO_2$ cycle in its production, making a positive climate impact compared with the continued use of fossil natural gas. Biomethane is produced locally: This increases regional value chains and reduces dependence on national gas imports.

## BROAD APPLICATIONS

The purity of biomethane makes new applications possible that do not exist for biogas yet. For example, biomethane can be converted into heat and electricity in an energy-efficient way in any natural gas-powered CHP. Due to the gas grid, the production site and the utilisation site are separated, i.e. the heat produced by the CHP unit can be fully utilised, e.g. for the heating of buildings.

## BIOFUEL

Biomethane can also be used as a biofuel to decarbonise the transport sector. Compressed as Bio-CNG or liquefied as Bio-LNG, biomethane is available for a wide range of applications. Whether in transport, shipping or even air traffic, up to 90 % of harmful $CO_2$ emissions can be saved. This is because biomethane only releases as much $CO_2$ as the raw biomass has previously absorbed from the atmosphere. If slurry, manure and organic residues are used as feedstock, biomethane actually has a positive carbon balance.

## MAXIMUM FLEXIBILITY

Biomethane is one of the most flexible and transferrable forms of renewable energy. Whether for electricity, heat generation or as a transport biofuel, there are many possible uses for biomethane. A useful by-product of biomethane production is $CO_2$, which can also be captured and beneficially used in many industries such as food and beverages and horticulture.



# agriPure®
# The system for biogas upgrading

## A PERFECT SYSTEM

The innovative and sustainable agriPure® biogas upgrading plant was originally developed by agriKomp in 2015.

The biogas upgrading process converts biogas produced by anaerobic digestion into biomethane using special membranes. There are several pre-treatment steps to clean and condition the biogas. The biogas is then compressed before entering the membranes which are used to separate the methane ($CH_4$) and carbon dioxide ($CO_2$) gases at a molecular level. After this upgrading process, the product biomethane can be sent to the gas grid or further compressed or liquefied for use as transport fuel.

## COMPLETE SOLUTION

With agriPure®, we offer a complete solution for anaerobic digestion and biogas upgrading: from biogas plants to biogas pre-treatment to biogas upgrading systems. agriKomp is the right choice for your project!

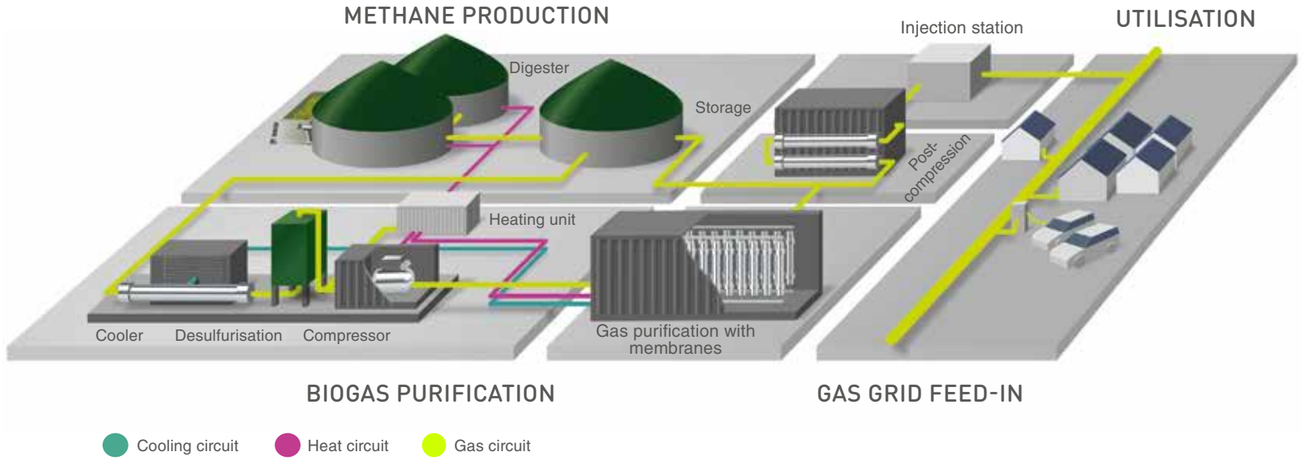
Our service network is well established and international with experienced service engineers and good spare parts availability. Your agriPure® plant will receive a well-coordinated and reliable service support, providing the best opportunity for a long and trouble-free plant lifespan.

## PROVEN SEPARATION TECHNOLOGY

We have chosen a proven and reliable technology for our membrane modules. We equip our agriPure® upgrading system with SEPURAN® Green membranes from EVONIK. The separation membranes operate according to the principle of selective permeation. The membranes are made of several thousand fine hollow fibers, which guarantee very good selectivity. They separate the gases in the raw biogas and produce a methane concentration of up to 99 % in the product gas. The innovative technology consists of three stages and enables optimum treatment efficiency with minimal methane losses, thus achieving maximum biomethane yield.

## YOUR BENEFITS AT A GLANCE

- Selected high quality components
- Fully automated system, easy to operate
- On-line control functionality
- Comprehensive service support
- Critical spare parts stock availability
- Good energy efficiency / low operating costs
- ≥ 99.4% methane recovery
- Sophisticated heat recovery
- Modular system: suitable for expansion
- Fast system re-start to grid-quality gas
- Industry leading membrane performance
- No use of cleaning chemicals
- No wastewater to be treated
- No process heat required




## THE PROCESS FROM BIOGAS TO BIOMETHANE

**1. Biogas production**
As a biogas plant manufacturer with more than 20 years of experience and almost 1,000 operating plants worldwide, we offer a wide range of plant configurations made of standardized and high-quality components, tailored to the needs of our customers. Seamless spare parts supply, an extensive service network and technical updates ensure trouble-free operation over the entire plant lifetime.

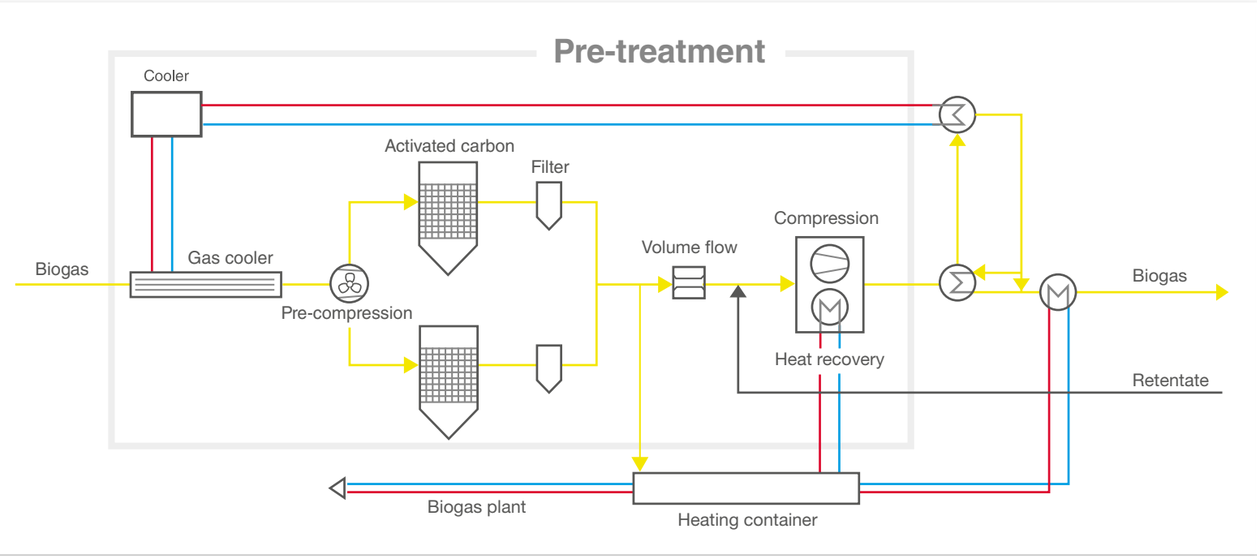
**2. Pre-treatment**
The biogas comes from the biogas plant as a mixture of $CO_2$, methane and a small amount of other gases and is desulfurized in the pre-treatment stage with activated carbon, filtered and dried to protect downstream components from wear or damage. The pre-treated gas is then compressed to 16 bar and fed into the membrane stage. The pre-treatment unit is also developed and manufactured by agriKomp.

**3. Upgrading / Purification**
The pre-treated and compressed biogas enters a membrane separation process, yielding a methane rich product gas and a $CO_2$ rich off-gas stream. The innovative 3-stage membrane configuration can produce a biomethane purity up to 99 %. The membrane separation stage and control system is housed in a single bespoke container.

**4. Feed-in / Injection**
The biomethane injection unit is connected between the biogas upgrading plant and the gas distribution grid. Its functions are the more than calibrated measurement of the biomethane, gas quality measurement, conditioning, odorization and pressure increase to the grid pressure.

**5. $CO_2$ applications**
The $CO_2$ removed from the biogas can be captured and recovered by liquefaction. This $CO_2$ can be used in many industries, for example air enrichment for greenhouses and in food and beverage production.

# agriPure®
# Pre-treatment and housing





## 1. COOLING / CONDENSATE REMOVAL

The raw gas (biogas) from the biogas plant will be fed into the pre-treatment. First step is the cooling of the biogas and separation of condensate. The gas is cooled and dried before entering the desulphurization unit. This extends the life of the activated carbon and of the compressor, which are high cost components.

## 2. PRE-COMPRESSION

The biogas is initially pressurised using a blower. This both improves performance in the main compression stage and also increases the gas temperature to an optimum level for treatment in the activated carbon filters.

## 3. BIOGAS DESULPHURISATION

Desulphurisation, as the 3rd step of the pre-treatment process, is performed by adsorption and oxidation in heat-insulated stainless-steel vessels.

By using stainless steel vessels we can provide high resistance to temperature, solar radiation and corrosion. The vessels are filled with high quality activated carbon. The conditions of the desulphurization step are chosen to maximize the loading of the activated carbon and to minimize the contact time of the deposition of hydrogen sulphide ($H_2S$). This results in a more efficient removal of $H_2S$ per unit volume of activated carbon consumed and lower operational costs for the customer.

For checking filter performance and $H_2S$ breakthrough, gauge connections are provided within the filter.

## 4. COMPRESSION

The main high-pressure compressor is a single-stage, oil-injected screw design. Its function is to bring the raw gas to the required pressure for the membrane separation stage.

It is skid mounted with integrated sound protection hood, expandable with optional silencers. The control cabinet is installed outside the EX-zone in a separate container. Above-ground pipework and pipe connections between the compressor and the upstream and downstream plant segments are made of stainless steel. The compressor is connected to the process control of the complete plant and uses a variable speed drive which controls the power and gas flow. The compressor is equipped with oil pre-separation, overpressure valves and bypass system. The compressor is also connected to the plants heat recovery system.

## HOUSING (CONTAINER)

The high pressure gas system with LEL (lower explosive limit) monitoring and the separation membrane modules are installed in a specially designed heat insulated container. The container is protected with a corrosion resistant coating inside and out. The plant control cabinet and the compressor switchgear are housed separately allowing the possibility of future system expansion. Inside areas use waste heat to maintain a stable temperature with electrical trace heating to protect against freezing.

Container 1: Membrane modules and high pressure gas system with LEL monitoring
Container 2: Plant control cabinets
Container 3: Control cabinet for compressor

Using the latest compact membrane technology also allows plenty of internal space for our service technicians to do their work.


agriPure® Container

agriPure® Container

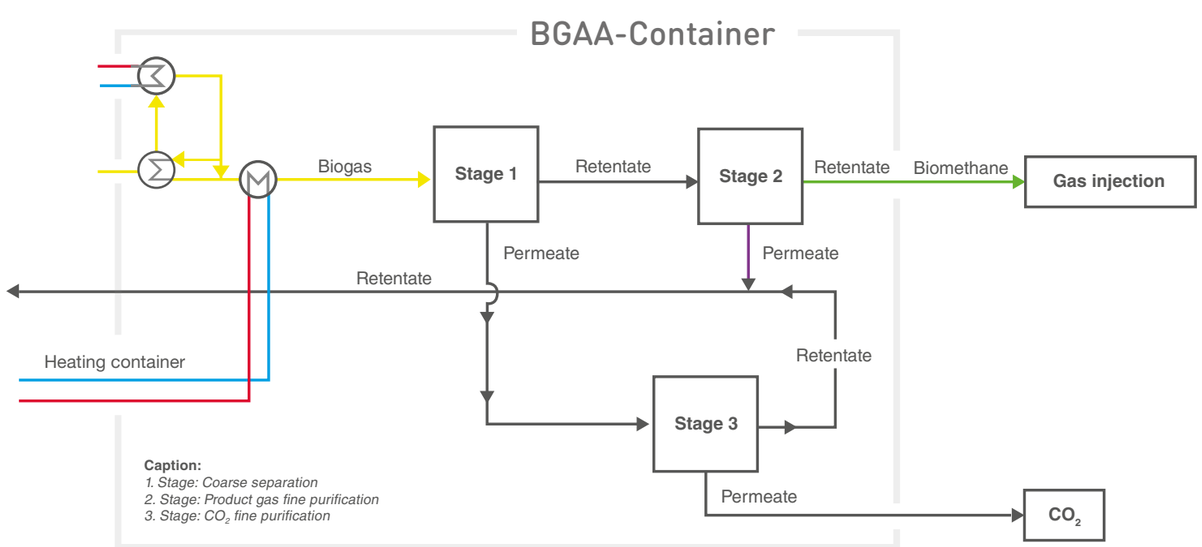
# Gas purification and membrane separation

## MEMBRANE MODULES

As a highly efficient solution for biogas purification, agriKomp uses EVONIK Sepuran® Green membrane modules. Gas separation membranes operate according to the principle of selective permeation by a membrane surface.

**Selective permeation**
The difference in size and solubility of biogas molecules leads to different permeation rates through the membranes. While carbon dioxide or water passes through the membranes at a fast rate, methane is retained (slow diffusion rate). The three-stage purification technology allows purifying performance of more than 99 % to be achieved and represents a flexible and scalable solution thanks to the modular system.

**Water and oil removal**
Following compression, water and oil must be removed from the compressed gas to achieve the adequate purity required for the membrane separation process. This is done by cooling and separation in coalescence filters in the main compressor and by reheating and fine separation on activated carbon with subsequent dust removal in the upgrading unit.




## 3-STAGE MEMBRANE SEPARATION

With the clever 3-stage separation process, recycling flows are minimized and the energy costs of biogas upgrading plants optimized. This is how it works:

Raw gas flows through stage 1 which is the primary separation where the methane-rich fraction continues to stage 2 and the $CO_2$-rich fraction is fed into stage 3.

In stage 2 the methane-rich fraction from stage 1 is further purified and becomes the product gas (biomethane) for grid injection or CNG/LNG production.

In stage 3 the the $CO_2$-rich gas is an output that can also be collected through an additional liquefaction step. The methane-rich fraction is recirculated to stage 1.

**Internal gas recirculation**
The methane-rich gas from stage 3 and the $CO_2$-rich gas from stage 2 are recirculated to stage 1 for another separation cycle; approx. 40 % of the treatment volume in standard operation.

**Product gas measurement**
The pressure of the raw gas entering the membrane separation stage is regulated by a process controller and in partial load operation delivery pressure is controlled via the compressor variable speed drive.

At the upgrader outlet, a safety shut-off valve is provided to meet the requirements of the grid operator. If gas export is not possible then the product gas can be returned to the biogas plant gas storage.

**Flexibility**
The agriPure® upgrading technology is a modular and flexible design that can readily adapt to changing flows and gas compositions. The standard capacity range is from 150 $Nm^3/h$ – 2,000 $Nm^3/h$ raw gas input.

# agriPure®
# Further important components

## AUTOMATION

The upgrading plant control system is substantially automated, ensuring safe and convenient operation. Operator intervention is minimal and generally limited to routine daily inspections and attention to any notifications of operational disturbance. All essential components and sub-controllers are linked with the main plant control and diagnostics and system maintenance activities are possible via remote access.

- PLC programming based on Siemens Simatic
- Visualisation Win CC
- Integration of the high-pressure compressor controller into the plant visualisation
- Integral data management and operation data collection
- Possibility of remote access

## HEATING SYSTEM

The agriPure® heating system is a 'plug and play' containerised boiler system with integrated heat recovery. The purpose of the system is to deliver process heat to the digesters and other heat users depending on available capacity. The boiler runs on biogas taken after the pre-treatment stage and supplementary heat is also collected from the compressor and upgrader gas circuit.

By integrating heat recovery from the pre-treatment process, our heating system is outstandingly efficient. Excess heat from the compressor, gas recirculation and gas cooling is fed into the heating circuit - a sophisticated system with the objective of providing the most efficient biomethane plant design.

## HEAT RECOVERY SYSTEM

A good heat recovery system helps to ensure high efficiency of the whole plant. The available heat ($kW_{th}$) corresponds to approximately 50 % of the electrical power consumption of the compressor ($kW_{el}$). The compressor uses oil for lubrication which heats up during operation and needs to be cooled. As a back-up measure of the system, the compressor can also be cooled using integrated emergency coolers. In addition to the compressor, heat is also recovered from gas cooling and the combined heat recovery is located in the heating system container.

## GAS ANALYSIS

The system gas flow analysis is a single integrated system:

- Raw biogas input – measured for: $CH_4$, $CO_2$, $O_2$, $H_2S$
- Hydrogen Sulphide ($H_2S$) - measured before, during and after activated carbon filter.
- Oxygen ($O_2$) in biogas - measured for upper explosive limit
- Biomethane (product gas) – measured for $CH_4$, $CO_2$, $O_2$

## POST COMPRESSION

For feeding into high-pressure grids, the gas grid operator requires a higher pressure at the transfer point. For this case, we offer a complete post-compression solution that is placed between the biogas upgrading unit and the injection station and is a single integrated unit. The post-compression set consists of a buffer tank and compressor (including switch cabinet), which is enclosed in a custom-built container.

## INJECTION STATION

The injection station is used to analyse and regulate biomethane to be injected into the grid. The station is usually owned by the network operator and is often also built and operated by the network operator.

**Essential functions:**

- Structural connection between the biogas upgrading plant and the gas grid.
- Calibrated measurement of the biomethane (measurements relevant to billing, such as gas volume measurement and measurement of calorific parameters)
- Gas quality measurement
- Conditioning of the biomethane (adaptation of the combustion properties of the biomethane to those of the natural gas in the gas grid)
- Pressure regulation of the biomethane to meet the network pressure



# Case Study - The 1st biomethane plant with $CO_2$ recovery in France

## THE PROJECT

Four agricultural farms have come together near Nantes to found the operational company SAS Métha Treil: two livestock farms and two vegetable farms. For the implementation, SAS contracted agriKomp, which realised all processes of biogas production, pre-treatment and upgrading to biomethane in a complete solution.

"Having a single supplier for the design and construction of the plant guaranteed us a single interface and avoided finger-pointing between the installers of the different works in case of disputes," comments Erwann Bocquier, Chairman of SAS.

"We also chose agriKomp because of its expertise in components. The paddle agitator Paddelgigant®, which was developed and manufactured by the company, convinced us. In addition, there was the wide range of different tanks and gas storages. We visited several plants and it appeared to us that this solution was the best, considering our requirements."

The plant, which went into operation in December 2019, is an agriPure® biomethane plant with a upgrading capacity of 250 $Nm^3/h$ biogas. 120 $Nm^3$ of biomethane is currently fed into the grid each hour. The special feature of the plant is the first $CO_2$ recovery system in France, which perfectly completes the plant design.

"In terms of our responsible management, we decided to use our entire resources and focus on feeding biomethane into the grid," explains Erwann Bocquier.

## UNIQUE PLANT CONFIGURATION

The site operators have installed technology allowing the recovery and utilisation of $CO_2$, which is a unique configuration for a biogas plant in France. A cold distillation process is used to liquefy the separated $CO_2$ from the biogas upgrading process. The liquefied $CO_2$ is sold to vegetable farms to improve plant growth in their greenhouses. Approximately 1,500 tonnes are to be produced per year.

"From tomato residues, we make $CO_2$ to improve the growth of tomatoes. This is a positive cycle," says Aymeric Egonneau, one of the purchasers.

## SEAMLESS IMPLEMENTATION FOR AN INNOVATIVE PROJECT

"One of agriKomp's strengths, in addition to its 20 years of experience in the business, is project management and supervision" , as Bocquier points out.

For every phase of the development, from feasibility study and subsidy application through to plant construction and operational support, the agriKomp team have used their combined knowledge and experience to make the project a success. Métha Treil is a real technological innovation and yet it took less than 2 years from the idea to the injection of biomethane into the grid.“

## AIM TO SUPPLY 10% OF MUNICIPALITY GAS CONSUMPTION

Farm manure and silage from the company's own livestock farms make up almost 95 % of the input, which is utilised in two 1,520 $m^3$ digesters and a 4,500 $m^3$ secondary digester. The digesters are heated with a biogas boiler and the recovered heat from the $CO_2$ liquefier and compressor. The plant is fed with a Vielfraß® solids feeder and connected PreMix unit.

Approximately 5,880 t of cattle manure, 2,800 t of cattle slurry, 6,480 t of intercrop silage and 2,000 t of maize silage are used. The input materials are supplemented or replaced by vegetable residues and non-marketable (by-)products from vegetable producers. Depending on the type of vegetable residues, the input materials are adjusted. Annually this substrate mix produces about 2,000,000 $m^3$ of biogas and about 15,000 $m^3$ of digestate.

"We don't grow specific plants to supply the biomethane plant, but rely on circular economy" , says Erwann Bocquier, one of the operators.

The resulting digestate is separated with a Quetschprofi® and spread as high-quality fertiliser for the plants again. The biomethane produced is fed directly into the nearest GRDF grid. Currently, this contributes 8 % of the gas consumption of the municipality of Machecoul-Saint-Même. The objective is to produce 10 % of the consumption. This has already been taken into account in the plant design, so that production can be increased in the coming years without construction measures.

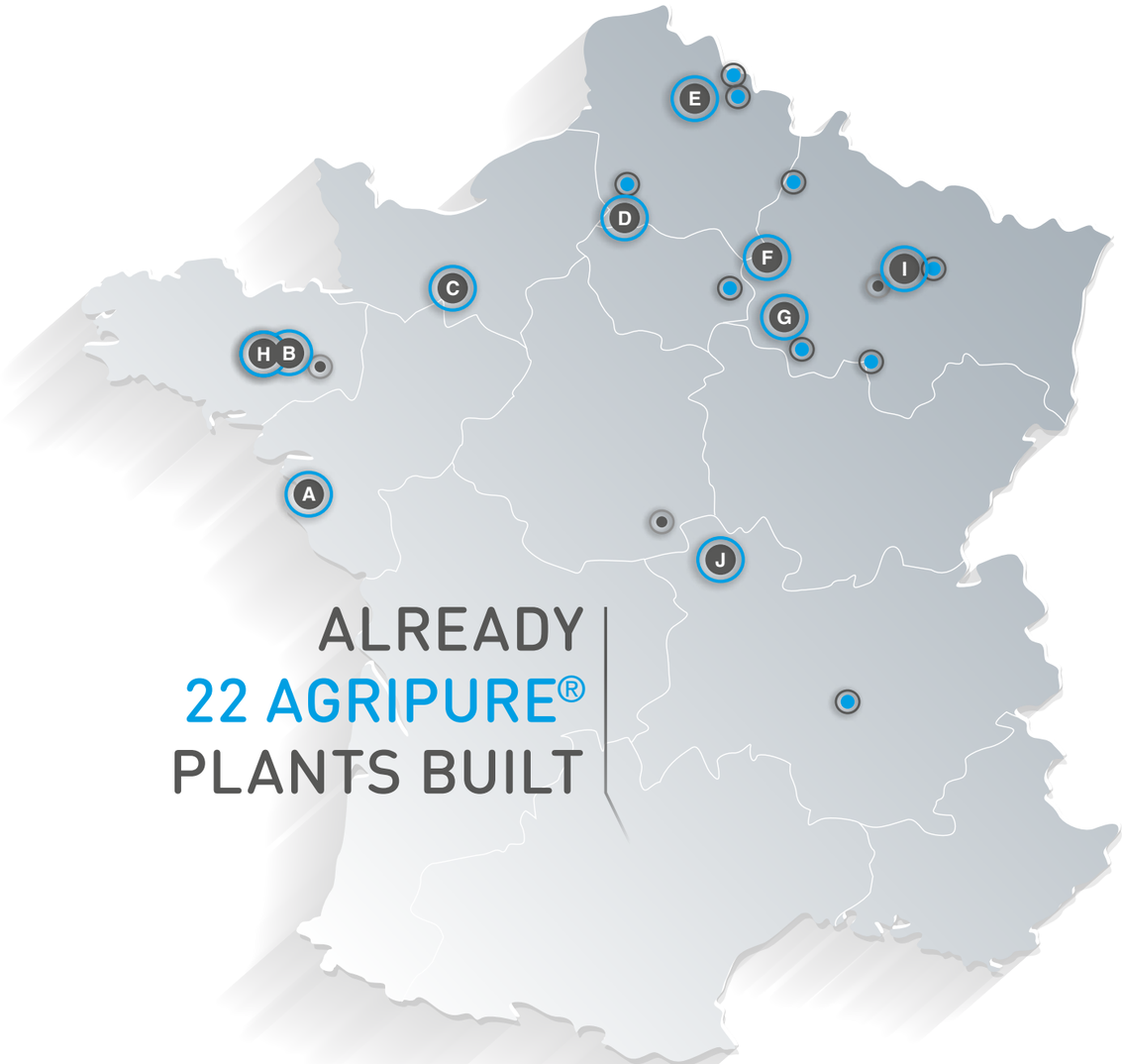
## "EVERYTHING FROM A SINGLE SOURCE" SAVES UP TO 80,000 EUROS P.A.

"It is always interesting to be involved in the entire planning and realisation of a biogas plant, as this enables synergies," says Nicolas Dromer, head of large-scale projects at agriKomp. With this holistic concept, the operator has only one company which guarantees the technical availability of the plant. The clever linking of individual processes increases the efficiency of the entire system. At Métha Treil, a sophisticated heating concept ensures savings. The recovery of heat from $CO_2$ liquefaction and the compressor, as well as the use of raw gas to heat the digesters, enables an additional yield of 1 % biomethane. If one considers these and other measures, such as low consumption of activated carbon in the raw gas conditioning through upstream biological desulphurisation in the digester and particularly efficient thermal insulation of the tanks, savings of up to 80,000 euros per year can be achieved.“

## WHAT IS PLANNED FOR THE FUTURE?

"In our surrounding area, there are many companies that demand green gas". Erwann Bocquier notes. "Today, the production capacity is 135 $Nm^3/h$ biomethane, but it is planned to double"says Dominique Pile.

# Our biomethane references speak for themselves




ALREADY
22 AGRIPURE®
PLANTS BUILT

At the beginning of 2021, 13 agriPure plants were in operation. Six plants are currently under construction and will feed biomethane into the grid before the end of 2021. Three more plants under construction will go into operation at the beginning of 2022. A further 28 plants are planned, with construction to begin in the next 2 years.

- Commissioned / in commissioning 2021 agriPure® plants
- In commissioning 2022 agriPure® plants
- In operation agriPure® plants

## REFERENCES

### A Métha Treil, SAS
Le Treil, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2019 |
| **Installed capacity:** | 265 Nm³/h biogas |

### B La Saude, SARL
Boisgervilly, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2020 |
| **Installed capacity:** | 125 Nm³/h biogas |

### C Méthacance, SARL
Fontenai-sur-Orne, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2020 |
| **Installed capacity:** | 250 Nm³/h biogas |

### D Chemin du Roi, SAS
Saint Crepin Ibouvilliers, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2021 |
| **Installed capacity:** | 750 Nm³/h biogas |

### E Artois Méthagri, SAS
Boiry-Notre-Dame, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2020 |
| **Installed capacity:** | 400 Nm³/h biogas |

### F Bioénergie de l'Étang, SAS
Corribert, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2020 |
| **Installed capacity:** | 400 Nm³/h biogas |

### G Cappela Gaz, SARL
Les Grandes-Chapelles, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2021 |
| **Installed capacity:** | 500 Nm³/h biogas |

### H SAS Friche Margot
Boisgervilly, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2020 |
| **Installed capacity:** | 195 Nm³/h biogas |

### I Gaz2o, SARL
Bislée, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2020 |
| **Installed capacity:** | 250 Nm³/h biogas |

### J Besson Bioénergies, SAS
Besson, France

| | |
|---|---|
| **Type:** | agriPure |
| **Commissioning:** | 2021 |
| **Installed capacity:** | 315 Nm³/h biogas |