Business Case
GOLEM-ZERO

An algorithm for the biomethane injection into the grid

Who we are

For over 35 years, we have been innovating to protect people, infrastructures and the environment.

Founded in Italy in 1987 by Giorgio Giorgetti, **AUTOMA** specialises in the design, engineering and production of complete and reliable Made in Italy digital solutions for smart remote monitoring and control of oil, gas and water distribution and transport networks.

Advanced solutions for remote monitoring and control in the Oil, Gas & Water sectors

AUTOMA operates in over 40 countries, covering all continents with its solutions. Our global presence allows us to offer support and innovation everywhere, guaranteeing quality and reliability. We continue to expand and are ready to enter new markets, bringing our innovative technology to an increasing number of countries. To date, over 60,000 **AUTOMA** devices have been installed worldwide.

The **AUTOMA** team is composed of experts in the design of advanced solutions for remote monitoring and control of cathodic protection and odorant analysis, as well as for remote control and regulation of gas pressure stations.

Thanks to an advanced internal Research & Development department, which integrates feedback gathered from technicians and sales people in the field, **AUTOMA** is able to design devices and software that precisely meet the specific needs of its customers.

Your Partner in **Smart Technology**

The AUTOMA Philosophy

Sharing

Best practices based on thousands of projects implemented worldwide have enabled us to make significant technological improvements and validate our insights. We are proud to present these finely tuned and perfected solutions to our stakeholders, as well as our research activities to further improve them over time.

High specialisation

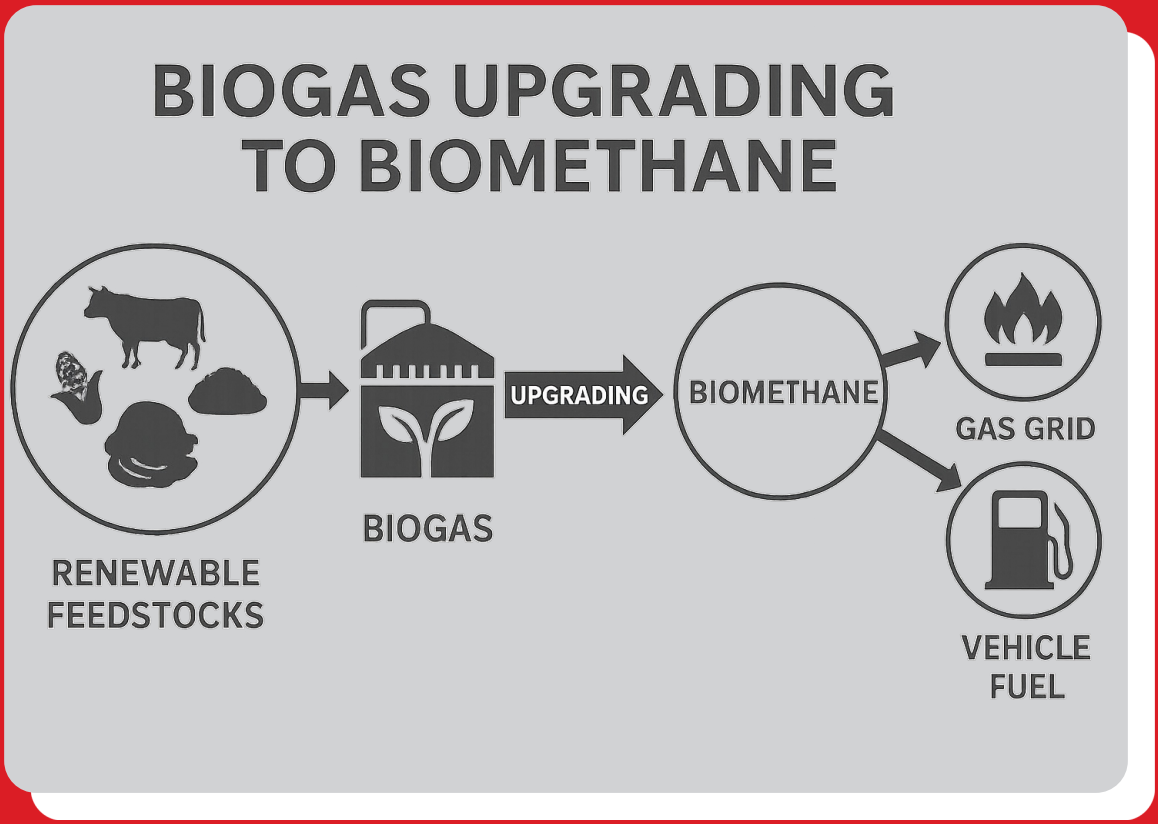
This is one of our greatest strengths, which has always allowed us to identify high-performance, reliable solutions built with a long-term perspective. All this is possible thanks to the experience we have gained in the field alongside the leading experts in the sector: our customers.

Solution orientation

We are committed to designing and manufacturing solutions with an eye to the future and with the ability to grow, evolve and adapt over time, meeting the changing needs of the market in general and our customers in particular.

Background
Upgrading biogas to biomethane

The upgrading of biogas to biomethane is a technological process that converts biogas produced from renewable sources—such as livestock manure or agricultural biomass, into biomethane, suitable for injection into the natural gas distribution grid.



The process of upgrading biogas into biomethane is a complex purification process that aims to **increase the quality of the biogas** by removing impurities and the CO_2 present in it. The resulting methane is then collected, compressed, and referred to as biomethane.

Biomethane generated through the upgrading process is chemically comparable to natural gas and can be injected into existing infrastructures and used alongside other sources to meet growing energy demands.

Anyone operating a biomethane plant has the **right to request a connection to the transmission or distribution network**. The gas distribution operators must ensure that the biomethane produced is injected into the network with priority over other gas stations (i.e. NTS offtakes).

It should be noted that the amount of biogas produced and its conversion into biomethane is significantly smaller than the volumes that is available in the NTS offtake. Moreover, this quantity is variable depending on the circumstances surrounding both production and conversion processes.

Due to the variability and limited quantity of biomethane, the priority is to inject all of the biomethane made available by the producer, provided it meets the required quality standards.

Several scenarios may occur during normal operation:

- Biogas is being produced, and the upgrading plant maintains a regular supply of **biomethane in both quantity and quality**. In this scenario, there are ideally no obstacles to the normal operation of the injection system.
- The pressure measured at the inlet of the regulator tends to increase progressively due to an increase in biomethane production from the upgrading. In this case, the risk is that **an overpressure phenomenon occurs**.
- The same pressure measured at the inlet of the regulator drops sharply due to a **reduction in biomethane production** from the upgrading. This creates a risk that the inlet pressure falls to a lower level than the outlet pressure which causes the injection to stop.
- The flow rate of the upgrading system is **higher than the maximum permissible flow rate** of biomethane, i.e. the producer generates more biomethane than contractually agreed with the gas distributor.
- The biomethane from the upgrading system **does not have sufficient inlet pressure** to overcome the grid pressure and keep the regulator operational. This scenario may lead to **a shutdown of the injection system**.
- The outlet pressure of the regulator undergoes a temporary increase in pressure due to the decrease in consumption. Under these conditions, the network pressure could reach the regulator's setpoint which cuases the injection to stop.
- The biomethane from the upgrading system d**oes not meet the required quality parameters**.
- There is **a problem with the systems/equipment** (security alarms, prevention alarms, faults, power failure) that **forces plant to stop**.

The gas distribution operator is required **to guarantee feed-in priority to the biomethane producer**; therefore, the injection system must always deliver biomethane to the grid whenever it has biomethane suitable for feed-in and must take precedence over other natural gas stations connected to the same network.

We have the SOLUTION

BUSINESS CASE

GOLEM-ZERO: an algorithm for the biomethane injection into the grid

At one of Italy's leading Gas Distribution Operator (GDO), **AUTOMA** was tasked with guaranteeing that biomethane produced on-site could be injected into the local gas network without interruption. The project centred on the deployment of **GOLEM-ZERO**, **AUTOMA**'s dynamic regulation system, which modulates the pression to maximise the volume of the biomethane injection keeping the level of injection as constant as possible. Because Italian regulations grant biomethane producers feed-in priority over conventional natural gas, the ideal situation would be having a system able to deliver every cubic metre of compliant biomethane to the grid ahead of other sources—an objective **GOLEM-ZERO** now secures around the clock.

Executive Summary

Customer: a major Italian GDO

Challenge: optimize the injection of biomethane into the natural gas grid and guarantee feed-in priority to the producer, despite hour-to-hour swings in flow, pressure and network demand.

Solution implemented: the configuration implemented is a fully Automa-integrated solution: the **GOLEM-ZERO** device is directly connected to the **Automa G5P RTU**, which communicates with the ***Automa WebPressure*** software.

Key results: during its first six months in service, **GOLEM-ZERO** eliminated all pressure-related injection stops, keeping the inlet pressure within a specific range, and dynamically modulated surplus flow to prevent over-injection penalties.

Benefits: ≥70 % downtime reduction, 35 % fewer on-site call-outs, full capacity utilisation.

Revenue impact: over-injection penalties eliminated and an extra 6 - 8 % of biomethane injected, delivering a pay-back in a few months.

Customer Profile

One of Italy's largest independent natural-gas distributors, the company manages roughly 72 000 km of pipelines across 18 regions, supplying reliable energy to about 4.9 million end-users in 2 200+ municipalities. Backed by a workforce of some 2 200 employees, its regulated distribution business generated circa □732 million in revenue (2022) and continues to invest in digitalisation and network efficiency to ensure a secure and resilient service at national level.

Sector	Natural-gas distribution (regulated utility).
Market position	Second-largest gas distributor in Italy, with ≈ 57 000 km of network and ~3.8 million end-users across 18 regions.
Biomethane footprint	• 6 production sites already connected – enough energy for > 23 000 households. • Built Italy's first reverse-flow station (Terranova dei Passerini) so surplus biomethane can be pushed back into the transmission grid.
Regulatory role	Operates under the national feed-in priority rule, ensuring every compliant cubic metre of biomethane is dispatched before gas from conventional NTS offtakes.
Technology & innovation	Pilots for hydrogen blending readiness, pressure-optimisation algorithms and an IoT data platform to digitalise 57 000 km of pipelines.
ESG commitments	Targets 60 % cut in Scope 1-2 emissions by 2030 (-40 % already achieved vs 2021) and Net-Zero by 2050; OGMP 2.0 "Gold Standard" on methane emissions.
Why Biomethane	• **Regulatory & market drivers** – Feed-in priority for biomethane lowers regulatory risk and ensures predictable returns on new grid connections. • **Decarbonisation target** – Cuts Scope 1-2 emissions by 60 % by 2030 and reaches Net-Zero by 2050; biomethane is a key lever for reducing fugitive methane emissions. • **Domestic supply & circular economy** – Adds renewable gas equal to the needs of > 13 000 households while valorising agricultural waste and boosting national energy security. • **Future-proof infrastructure** – Prepares the network for green-gas blends (e.g., hydrogen) and leverages IoT digitalisation to enhance resilience and safety.

Challenges

The biomethane plant presents the same **vulnerabilities seen at many injection points**: a limited pipeline volume, a limited buffer volume, and a production profile that can swing from 0 % to 100 % in a single day. Output may also be interrupted by feedstock availability or by **faults in the upgrading plant**. Under such circumstances even minor pressure or flow oscillations can make conventional pneumatic regulator-based entry points operate intermittently, with alternating periods of injection shutdown and over-injection that may also expose to contractual penalties.

To overcome these issues the customer required a system able to:

- Check the flow. The solution must cap the flow below a contractual limit using the flow-meter readings; only after that must regulate and modulate all the other operational parameters.
- Hold sufficient injection pressure once the flow limit is satisfied.
- Maintain continuous injection from night-time minima to daytime peaks by modulating in real-time and avoiding pressure-related fluctuations of biomethane injection.
- Comply fully with Italy's feed-in-priority rule, so every compliant cubic metre of biomethane enters the grid ahead of other gas sources.
- Cut trips and manual call-outs while providing full traceability for the network operator.

Proving that **GOLEM-ZERO by AUTOMA** can satisfy this logic of **modulating flow first** and then **pressure** is the focus of the present case study.

AUTOMA's SOLUTION

GOLEM-ZERO: a breakthrough in dynamic regulation

The **GOLEM-ZERO by AUTOMA** dynamic regulation system, designed and patented by **AUTOMA**, is a combination of intelligent electronics and an electromechanical system that **drives the regulation screw** of a standard pneumatic pressure regulator via an electric motor, indeed a smart actuator which turns out in a smart gas regulator.

GOLEM technology is based on a mechanical servomechanism that interacts directly with the drivers of the pressure regulators, supported by an advanced electronic system. Thanks to the **intelligence incorporated** in the system, **GOLEM-ZERO can operate in autonomous mode**, reducing the need for manual interventions. The system is **applicable to any controller model** and can be easily integrated into existing networks thanks to custom-designed adapters.

The power supply can be via the mains, but also via a photovoltaic system. During its development phase, either in lab or in the field, **safety systems** were implemented to avoid mechanical problems with possible seizure of the pilot adjustment screw.

The system is managed manually and remotely via any SCADA software or **WebPressure** (a suite developed by **AUTOMA** specifically for the industry), operates in fully automatic mode, working dinamically on the regulator's setpoint according to predefined logics. The **OLEM-ZERO** system communicates remotely with the **GOLIAH5P** (G5P), that is an **AUTOMA** RTU, or any PLC via Modbus or IEC-104 protocol. Instead, it uses an RS485 serial connection for local communication.

Flexibility by Design

- **Mechanical installation**

Easily retrofits onto any existing pressure regulator/pilot via custom-designed mechanical adapters.

- **Remote Control & Communication**

Seamlessly integrates with established SCADA and RTU systems using standard protocols.

- **Power supply**

Engineered with versatile and robust power management options, including backup systems.

Solar power available.

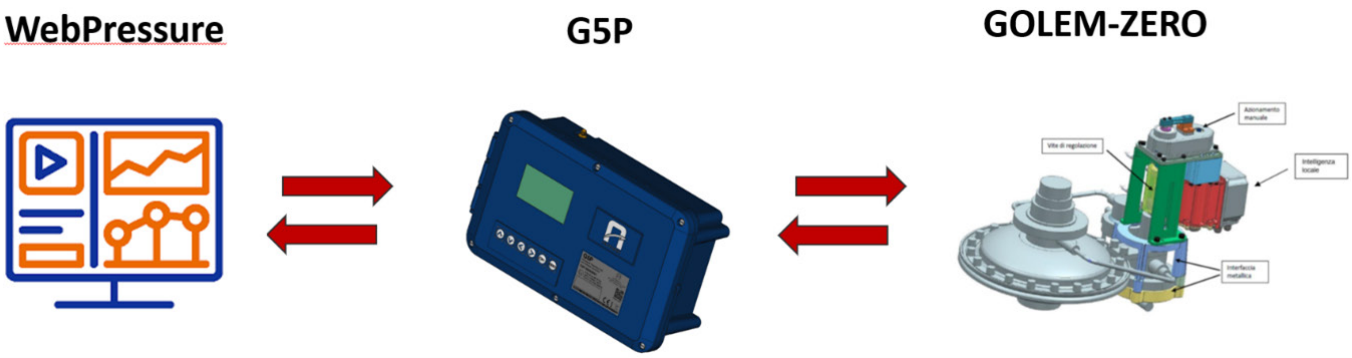
- **Mode of operation**

Dynamic setpoint management via embedded intelligence.

Architecture

Current Automa-Based Architecture

The configuration implemented in this project is a fully **AUTOMA**-integrated solution: the **GOLEM-ZERO** device is directly connected to the **AUTOMA G5P RTU**, which communicates with the **AUTOMA WebPressure** software.



Other available architectures:

- **AUTOMA Hybrid Solution** → SCADA + AUTOMA G5P + GOLEM-ZERO
- **Third Party Integration** → SCADA + ANY RTU/PLC + GOLEM-ZERO

SCENARIOS MANAGEMENT

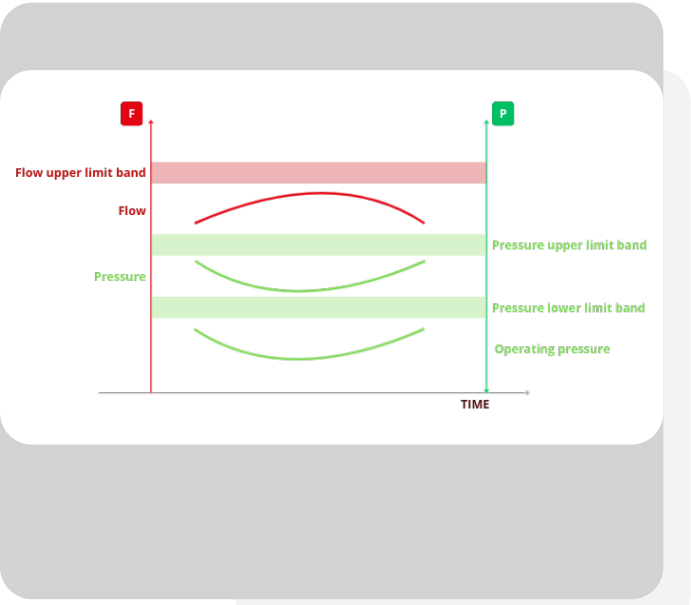
How GOLEM-ZERO keeps the entry point under control

Before any action is taken, **GOLEM-ZERO by AUTOMA** is continuously fed with readings from four key signals:

- **Inlet pressure** (upstream of the regulator)
- **Outlet pressure** (downstream, toward the grid)
- **Biogas flow rate**
- **Electric outage status** (backup supply only)

These real-time values feed a closed-loop algorithm that decides whether the station is in its **Typical Operating Mode** or in one of four exception scenarios—**Decrease in Inlet Pressure**, **Increase in Inlet Pressure**, **Increase in Flow Rate**, **Upgrading System Anomaly**.

For each condition **GOLEM-ZERO** issues millisecond-level commands to the actuator, increasing or decreasing the regulator (or pilot) aperture to **keep pressure and flow inside pre-set corridors**, and the **setpoint higher than the network pressure to ensure injection priority**. When the plant is healthy, the system merely fine-tunes; when a limit is breached, it intervenes immediately, restores stability, then returns to standby.



Typical Operating Mode

When the upgrading section is running at **full capacity**, it channels its **highest-quality biomethane** directly to the injection skid. Here **GOLEM-ZERO by AUTOMA** sets the regulators to an optimal set-point that ensures renewable gas feeds into the grid ahead of any conventional NTS offtake supply.

Within that set-point, **GOLEM-ZERO** works in closed loop, trimming valve positions several times a second to hold:

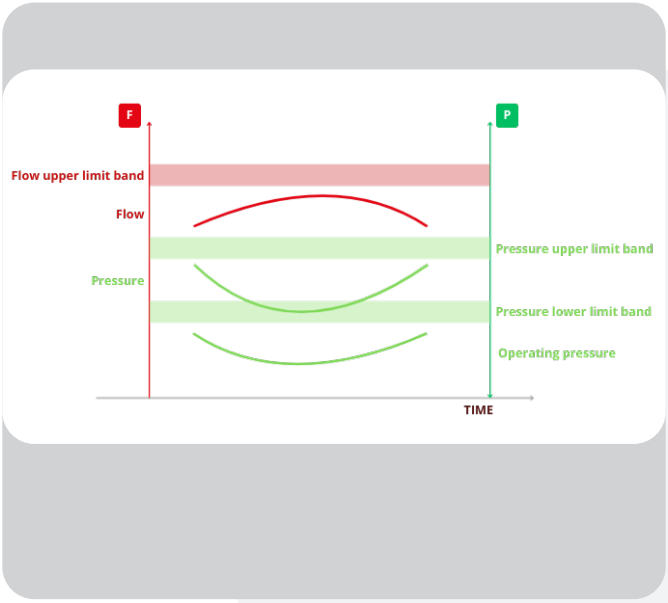
- **Inlet pressure:** maintained inside an operating corridor bounded by preset minimum and maximum values, each extended by a specified tolerance (± □P). This corridor always stays below the statutory maximum operating threshold.
- **Flow rate:** kept within a band defined by the chosen minimum and maximum plus their tolerance (± □Q), consistently remaining under the maximum permissible biomethane-injection rate.

The result is a **stable, fully compliant feed-in process** that delivers every available cubic metre of green gas to the grid with **no manual intervention**.

Decrease in Inlet Pressure

Whenever the inlet pressure slips into the **lower limit band**, **GOLEM-ZERO by AUTOMA** automatically steps in to **restore normal operating conditions**. Working in closed loop, it:

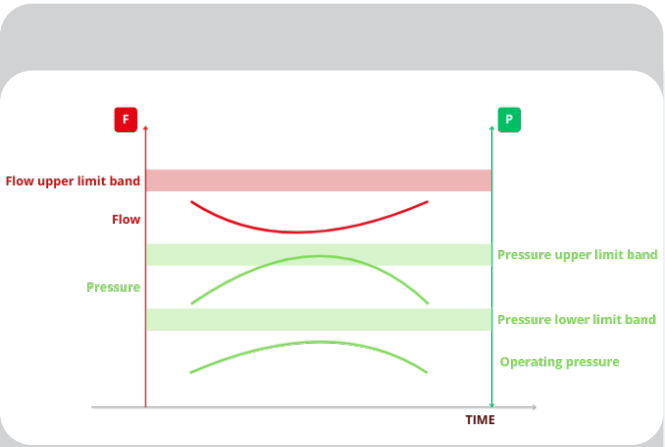
- **Operates on the regulator:** the actuator narrows the valve aperture, reducing the biomethane feed-in rate.
- **Rebuilds inlet pressure:** with less gas being drawn, pressure at the regulator inlet rises back toward the desired set-point.
- **Returns to standby:** as soon as the pressure climbs above the lower threshold, **GOLEM-ZERO** suspends modulation and switches back to its monitoring state, ready to intervene again if needed.



Increase in Inlet Pressure

Whenever the inlet pressure drifts into the upper limit band, **GOLEM-ZERO by AUTOMA** automatically intervenes to pull it back into the normal operating range. Working in closed loop, it:

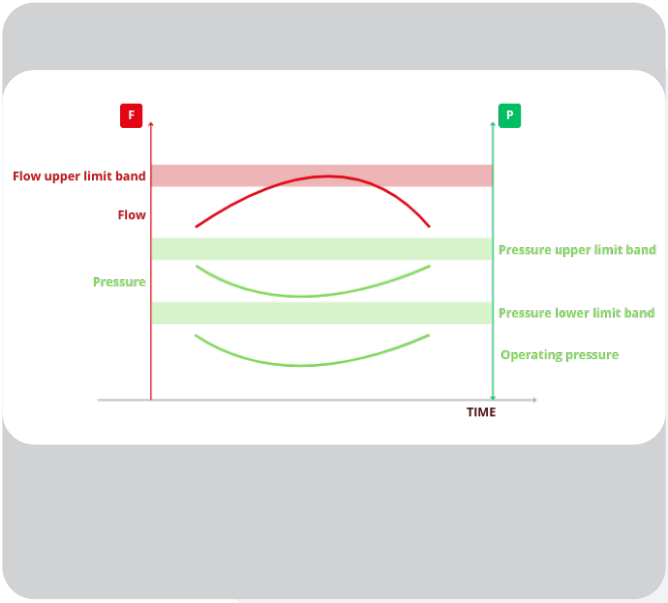
- **Opens the regulator:** the actuator widens the valve aperture, increasing the biomethane feed-in rate.
- **Relieves excess pressure:** the higher draw reduces pressure upstream of the regulator, bringing it back toward the target set-point.
- **Returns to standby:** once pressure falls below the upper band, **GOLEM-ZERO** stops modulating and switches back to monitoring, ready to act again whenever needed.



Increase in Flow Rate

Whenever the flow rate drifts into the **upper limit band**, **GOLEM-ZERO by AUTOMA** automatically steps in to restore normal operating conditions. Working in closed loop, it:

- **Adjusts the regulator:** the actuator narrows the valve aperture, reducing the biomethane feed-in rate.
- **Reduces flow rate:** with less gas being drawn, flow rate is brought back toward the allowed band.
- **Returns to standby:** as soon as the flow rate is below the upper threshold, **GOLEM-ZERO** suspends modulation and switches back to its monitoring state, ready to intervene again if needed.

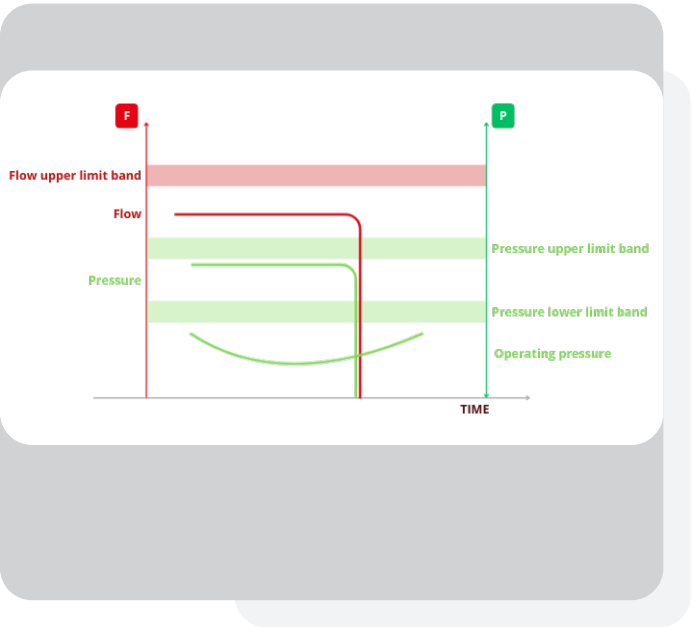


Upgrading System Anomaly

In the event of an upgrade system anomaly, the upstream pressure gradually decreases until the regulator motorization is lost. At that point it becomes impossible to reduce the pressure at the regulator and the regulator stops working—this is a fault condition, not normal service.

GOLEM-ZERO by AUTOMA detects this condition and, because the regulator is no longer active, **any command to the adjustment screw is ineffective**; therefore, the system:

- **Suspends active modulation**, avoiding futile manoeuvres.
- **Drives the regulator back to its optimal calibration set-point** so it is ready to resume service as soon as the upgrader restarts.
- **Enters standby mode:** it continues to monitor pressures and will re-engage regulation only when normal conditions return—that is, when upstream pressure is once again consistently higher than downstream pressure.



Benefits & Revenues

Why GOLEM-ZERO is really worth it

Operational efficiency and strategic upside with GOLEM-ZERO

Thanks to **real-time, remote and automated biomethane injection** management, **AUTOMA's GOLEM-ZERO** strengthens day-to-day operations, positioning the plant for **long-term success**.
Thanks to this approach, **AUTOMA** guarantees:

- **Continuity of service**, **GOLEM-ZERO** ensures stable injection, avoiding interruptions caused by pressure or flow fluctuations.
- **Reduction of field interventions**, automatic pressure balancing at the inlet and outlet points eliminates the need for frequent manual adjustments, which would normally require periodic visits to plants to ensure the prevalent input of biomethane into the network.
- **Increased grid stability**, real-time dynamic regulation reduces spikes and swings, protecting pneumatic regulators and improving overall grid reliability.
- **Rapid response**, **GOLEM-ZERO** reacts immediately to variations in biomethane production and network conditions, as in the case of back pressure, ensuring operational continuity.

These operational advantages originate directly from the overall performance of the plant:

As long as there is any gas demand from the network, field experience shows that the time during which the entry point cannot inject biomethane (typically around 10 – 12 % of annual hours) **is reduced by 70 – 80 %**, according to the field experience. This **massive reduction** in system downtime goes along with the **reduction in intermittency** of the entry point and turns it into a predictable source.

By smoothing production peaks before they hit network or safety limits, the **GOLEM-ZERO** makes possible to capture the full output of the upgrader—even at maximum load—so **no biomethane is line-packed nor flared**.

The **same dynamic** and closed-loop logic, supported by **comprehensive and real-time alarms**, lightens the workload for operations teams. Field data show that emergency call-outs and **unplanned shutdowns fall by up to 35 %**, translating into lower labour, travel and downtime costs and freeing skilled staff for higher-value activities.

Economic return of a GOLEM-ZERO in a biomethane plant

GOLEM-ZERO by AUTOMA creates economic value in two complementary ways.

First, it **removes penalties for exceeding contractual injection capacity**: by dynamically regulating pressure and flow in real time, the system keeps feed-in below the contractual ceiling, eliminating costs that currently eat into operating margins.

Second, it **sharply reduces downtime and not inkected biomethane**, that means at least **6 - 8 % more injection**, at the same production level: every cubic metre that leaves the upgrading section can therefore be billed, without investing in additional storage or pipeline capacity.

The combination of **zero penalties and higher billable volume generates incremental cash flow** that normally pays back the investment within just a few months.

	Value lever	Mechanism	Economic impact	Why it matters
Operational efficiency	**Intermittent reduction**	GOLEM-ZERO reduces technical downtime caused by pressure fluctuations, optimizing the biomethane injection.	Grid operators need to manage these fluctuations, which can involve extra operational costs for balancing the system.	Significant fluctuations can pose challenges for maintaining the stability and reliability of the gas grid.
	Optimal capacity utilisation	Automatically cuts peaks in overproduction before safety/network limits are triggered.	No flaring or waste of biomethane.	Maximises billable volume without investing in storage or line pack..
	Less O&M and call-outs	Real-time alarms + dynamic and closed-loop control reduce emergency shutdowns.	Up to 35% reduction in field interventions (man-hours, travel, downtime) compared to similar plants.	Direct reduction in operating costs and availability of personnel for higher value activities.
Economic value	**Penalty Free**	Dynamic pressure/flow control keeps the injection curve within the contracted limit at all times.	Elimination of penalties for ‘over-injection’ (typically 5-10 □/MWh or fixed amounts per event).	Penalties erode margins: eliminating them is equivalent to recovering profits already generated.
	More gas injected	Reduced downtime and flared biomethane.	Investment payback within just a few months.	Generates incremental cash flow.

CONCLUSIONS

Uninterrupted, priority biomethane feed-in and maximised grid-ready uptime

GOLEM-ZERO by AUTOMA does more than stabilise the injection of a biomethane plant: it turns it into a **predictable source, high-performance and revenue-generating asset**.

- **Technically**, the system keeps every reversible event under control by trimming valve position millisecond-by-millisecond, so **upstream pressure never stays outside its operating range and flow never breaches the contractualized limit**. In non-reversible events—an upgrading system failure, a power shutdown, or a quality alarm—**GOLEM-ZERO** moves each regulator back to its optimal calibration set-point and waits, poised for an immediate, clean restart. A built-in mechanical end-stop guarantees that, even in a motor fault, the **actuator can never force the station beyond safe limits**.

- **Operationally**, this real-time intelligence captures the full value of plant capacity: no biomethane is flared or dumped during production peaks, downtime for pressure-related fluctuations falls by up to 70 – 80 %, and call-outs drop by roughly one-third. The reduction of downtime translates into **at least 6 – 8 % more gas injected**—while the **removal of "over-injection" penalties protects margins** that would otherwise be eroded.

In sum, **GOLEM-ZERO by AUTOMA** safeguards every cubic metre of renewable gas, raises revenue, and cuts operating cost—all with a **fail-safe architecture ready for tomorrow's multi-gas networks**. It is therefore a practical, future-proof catalyst for **accelerating the energy transition while boosting the bottom line today**.

Welcome to the AUTOMA Blog

Ideas, Technology, Future

The AUTOMA Blog is online: a space created to share expertise, innovation, and solutions dedicated to the remote monitoring and control of Oil, Gas, and Water networks. Here you will find technical insights, case studies and useful perspectives to stay up to date with the latest industry trends.

Discover the contents of the AUTOMA Blog

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