

RESEARCH & INNOVATION

TRANSMISSION BUSINESS - **2018 REPORT & OUTLOOK**

WHY THIS REPORT?

This document is Teréga's third report on its Research and Innovation (R&I) activities. It provides an overview of the strategic programmes our teams are currently working on in accordance with the IMPACTS 2025 corporate plan. It refers only to the regulated activity of gas transmission, as part of which the French Energy Regulatory Commission (CRE) supports the R&I efforts of gas network operators.



TRANSITION ACCELERATOR

The current situation poses twin challenges with global repercussions: the energy transition and digital transformation. Against this background, innovation is clearly a major priority for Teréga.

To successfully deliver the IMPACTS 2025 plan, the innovation effort is focused primarily on the long-term future of the company as a gas infrastructure operator that leads by example. Innovation also reinforces its ability to assert itself as a powerful accelerator of the energy transition.

The Teréga innovation policy is designed to motivate and stimulate its people so that everyone is an acknowledged contributor to delivery of its corporate plan.

Teréga is also committed to inviting its wider ecosystem to play a full part in developing the company's strategic priorities. This was the rationale behind the first Teréga Innovation Day hosted in November 2018.

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Editorial

Cécile Boesinger



Head of R&I in the Teréga Strategy & Innovation Unit

“Today’s energy industry faces a series of major upheavals and unprecedented challenges:

the creation of a pan-European market, a dramatic increase in the number of market stakeholders, tighter regulation and the digital transformation. There are also the challenges posed by the energy transition, which is increasingly central to all our concerns and thinking. In France, the Energy Transition for Green Growth Law (LTECV), introduced in 2015, lays the foundations for the transformation that the energy system must embrace to become greener and more socially responsible. This system must evolve towards a low-carbon, renewable, diversified and decentralised energy mix, and move away from being a vertically structured system dominated by fossil fuels.

Gas in general, and the infrastructures operated by Teréga, are therefore central to this process of change.

Its IMPACTS 2025 corporate plan sets out the Teréga’s commitment to being a key facilitator of this energy transition.

Research & Innovation is integral to this framework at two levels:

- adapting infrastructures to accommodate the arrival of new gases (also known as green gases) by focusing work on their quality, the definition of acceptance thresholds, the management of new flows, etc.
- developing Smart Multi-Energy Grid projects that promote synergies between energy carriers (electricity, methane, heat, hydrogen, etc.) and their infrastructures.

The flexibility and adaptability of gas transmission and storage infrastructures make this resource a central link in tomorrow’s energy system.

Naturally, continuous improvement initiatives remain key priorities

for assured service continuity, security of supply and enhanced corporate responsibility.

This mission allows R&I to research and explore any new technology, technique or method with the potential to improve the integrity of engineered structures, installation performance, process digitalisation, personal safety, energy efficiency or environmental protection.”

▷ IMPACTS 2025 AND R&I... IMPROVING, SECURING AND ACCELERATING

The Teréga IMPACTS 2025 corporate plan is designed to enable the company to achieve its ambitions in tomorrow's energy landscape. It is structured around five key strategic priorities:

- Guiding the consumer and the market
- Improving efficiency and accountability
- Raising the profile of the company
- Securing and Accelerating
- Reinventing Teréga DNA

Two structural initiatives flow from the corporate plan: BE POSITIVE (the Positive Environmental Performance initiative that aims to achieve a neutral environmental balance in 2020, and generate environmental value thereafter) and PARI 2025 (the Accidents and Industrial Risk Prevention initiative). R&I plays a central role in this dynamic impetus through its IMPACTS 2025 Innovation Plan, which brings together six innovative programmes for the regulated activity of gas transmission.

THE SIX INNOVATION PLAN PROGRAMMES

IMPACTS 2025



INFRASTRUCTURE
INTEGRITY



OPERATIONAL PERFORMANCE
AND SAFETY



GREENHOUSE GAS EMISSIONS
CONTROLS AND ENERGY
EFFICIENCY



NETWORK AND SMART
GRID INTEGRATION



NEW GASES

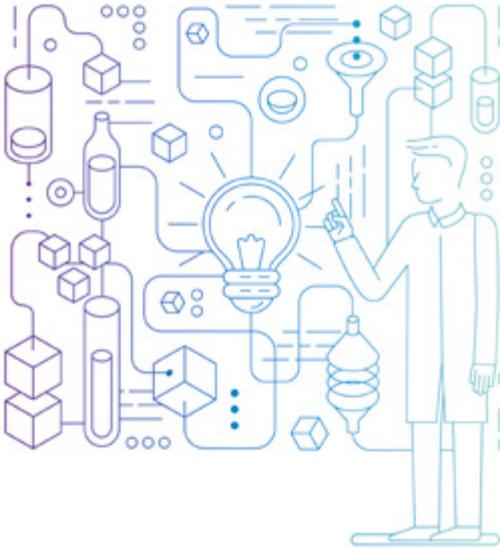


LOCAL INTEGRATION
& ENVIRONMENTAL FOOTPRINT

“Innovation focuses mainly on the two main issues of energy transition and digital transformation, but the priority mission of R&I is still to improve the competitive position of the company.”

Cécile Boesinger

Head of R&I in the Teréga Strategy & Innovation Unit



WHAT DEFINES AN R&I PROJECT?

In essence, an R&I project contributes to achieving the ambitions and targets set out in the IMPACTS 2025 Innovation Plan programmes.

To meet its operational needs, Teréga develops solutions that have a direct practical application for its infrastructures and the services offered to its customers.

The sphere of activity covered by R&I is therefore broad to cover three main aspects:

- improving and developing the knowledge and practices of Teréga
- testing and building prototypes to qualify technologies and new methodologies wherever feasibility is uncertain
- responding to integration issues within its operational environment

As an enthusiastic promoter of applied research, R&I conducts projects that can be directly deployed in Teréga's industrial facilities on completion of a development process of approximately three years. Once feasibility is established, the project moves into the industrial-scaling and roll-out phases. At this point, the project is no longer within R&I scope, and is passed along to the dedicated business teams for full deployment.



50+ employees

EVERY TERÉGA DEPARTMENT IS INVOLVED IN THE INNOVATION PROCESS, WHICH EQUATES TO AROUND 10% OF THE COMPANY'S WORKFORCE.



€5 million

THAT'S THE AVERAGE ANNUAL BUDGET ALLOCATED TO TERÉGA R&I.



30+ projects

FOCUSED ON TRANSMISSION, AND OVER 10 ON STORAGE ARE INCLUDED IN THE IMPACTS 2025 INNOVATION PLAN.



40+ partners

WITH COMPLEMENTARY SKILLS.



On 28 November 2018, Teréga hosted its first Innovation Day; a major initiative to disseminate its culture of innovation at all levels of the company.

▶ A win-win partnership strategy

To deliver the most effective response to innovation needs, the majority of Teréga R&I projects are conducted in partnership with a wide diversity of key stakeholders.

There are three main reasons for this extremely proactive partnership strategy:

- 1. To expand and develop internal teams expertise** in key technical disciplines by working alongside public and private research organisations, such as the University of Pau and Pays de l'Adour. These partnerships are very effective for knowledge enhancement projects, such as the impact of new gases on infrastructures. They often result in scientific publications.
- 2. To pool efforts** over the long term with other companies from the energy industry addressing joint issues, like with GRTgaz for projects

that primarily concern core business activities.

- 3. To support the development of innovative technologies or methods** with the potential to create value for Teréga (engineering consultants, SMEs and start-ups like Febus Optics). These partnerships facilitate the development of new solutions to problems faced by Teréga, and also help to identify new applications. They are particularly effective in delivering energy efficiency and infrastructure reliability improvements, as well as reducing environmental impact. They also enable the industrial-scale development of new technologies and non-mature channels related to facilitating the injection of more zero-carbon gas into supply networks.

Industrial demonstrator projects generally involve more complex collaborative arrangements that combine these three points, such as France's first industrial-scale Power-to-Gas demonstrator: JUPITER 1000 (www.jupiter1000.eu).

To further strengthen this partnership strategy, Teréga is expanding its commitment to Open Innovation and is also actively contributing to various French and international research associations: GERG (The European Gas Research Group), EPRG (The European Pipeline Research Group), CITEPH (Collaborative Technological Innovation in Energy Domains), ITTECOP (Land Transport Infrastructures, Ecosystems and the Landscape), the Pôle Avénia Geosciences Innovation Valley, CTBM (the French National Technical Centre for Biogas and Methanisation) and others.

▶ Teréga, a responsible, involved and high-profile stakeholder



The projects and programmes run by R&I promote Teréga nationally and internationally through various scientific publications and participation in research conferences and symposia. Some examples from 2018:

The World Gas Conference 2018 (WGC) in Washington (USA)

The R&I teams made two presentations on the future of natural gas transmission networks and the practicalities of injecting biomethane into them. Speakers: Cécile Boesinger, Guilhem Caumette and Thierry Reynaud.



Renewable Energy Gas Technology 2018 (REGATEC) in Toulouse

Teréga had an exhibition stand at the

sixth of these international conferences on research in renewable energies.



Smart Energies Expo 2018 in Paris

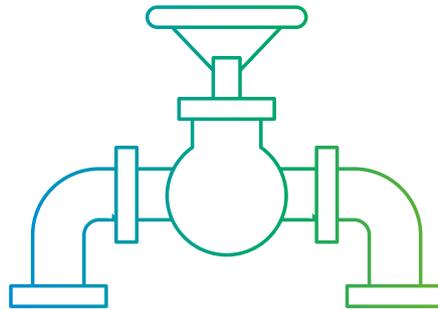
At this event, Teréga shared a stand with GRTgaz and GRDF to showcase the Smart Gas Grid and the energy transition R&I projects relevant to gas operators.



INFRASTRUCTURE INTEGRITY

Protecting and inspecting pipelines effectively using the best technologies and methods currently available





Teréga's status as a leading stakeholder in the European gas landscape imposes a responsibility to maintain **safety, reliability and availability** of its installations, at the same time as optimising network costs and performance. With more than 5,000-km of pipelines, the physical integrity of its infrastructures is an essential issue and **major challenge** for Teréga, highly supported by the PARI 2025 Accidents and Industrial Risk Prevention initiative.

In this respect, the R&I programme sets out to **develop and implement innovative technologies that facilitate the inspection of inaccessible structures** that are encased or underground, without the need to excavate. It also requires the company to be at the cutting edge of the latest developments in both **passive protection** techniques and methods for new structures (pipeline coatings) and **active protection** solutions (cathodic protection).

"R&I's role is to improve pipeline protection and inspection techniques, since these structures present significant technical challenges, such as accessibility, operating conditions, environmental variability, etc."

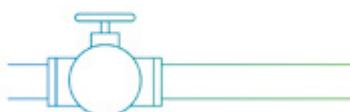


Rémi Lancien

Inspection Department Manager
and R&I Infrastructure Integrity Programme Manager

▶ Two R&I projects dedicated to pipeline inspection and protection

1 – Detecting pipeline defects and optimising cathodic protection



THE AIM

R&I has twin ambitions for this project: to develop an inspection technology for unpiggable small diameter pipelines to avoid their excavation and to gain a better understanding of corrosion factors to make cathodic protection more effective.

The approach

- A new non-destructive pipe inspection technology is currently being developed and tested. The data is compared with others currently used inspection methods to ensure a higher degree of robustness. Progress is being made and shared as part of ongoing collaboration with GRTgaz
- The behaviour of cathodic protection in sandy soil is a particular focus of research. The properties of new pipeline coatings are also being compared with traditional coatings

Progress to date

- Ongoing development of magnetic tomography technology in partnership with Skipper, and improvements in signal processing
- Inspection tests conducted in conjunction with the GRTgaz service provider, with comparison of test output data

Customer benefits

- Improved integrity and longer working life for network infrastructures
- Inspection cost optimisation

Future developments

- Optimising the algorithm reliability to reduce false alarms
- Improving weld defect detection
- Excavating the inspected pipelines to validate the results
- Improving corrosion risk analysis tools

WHY DO PIPELINES NEED TO BE INSPECTED?

Pipeline inspection is a non-negotiable duty for all gas network operators. The main risk posed by a lack of inspection is a gas leak that could have major consequences for Teréga as a company, as well as for its customers, local residents and the environment. So it is essential to conduct regular inspections using efficient techniques in conjunction with meticulous installation maintenance and appropriate protection solutions.



Magnetic tomography inspection of pipelines in conjunction with specialist contractor, Skipper.

WHAT IS CORROSION?

The main reason for metal corrosion is the presence of water. Corrosion is an electrochemical process which damages steel pipes and reduces their service life. Cathodic protection is an 'active' protection technique that counters corrosion. It works by applying a voltage to the metal surface of the pipe. It reduces its corrosion potential to a sufficiently low and acceptable level by significantly slowing the rate at which the metal corrodes.

2 - Innovation in duct inspection

THE AIM

The R&I ambition for this project is to arrive at a high-performance methodology that will enable 10,000 ducts used in the 5,000-km Teréga network to be inspected in the most effective way. Duct defect detection is a major priority for ensuring end-to-end network safety. Teréga is then engaged in an ongoing process of researching new duct inspection techniques via Open Innovation and monitoring developments nationally and at the European level

WHAT IS A DUCT?

This term refers to the steel or concrete casing used to protect underground pipelines against external mechanical stresses imposed by rail tracks, motorways, rivers, etc. Although ducts help keep structures safe and protected, inspecting them is a very labour-intensive task due to their difficult access and the high cost of excavation (road closures, river crossings, etc.).

The approach

- Development of a duct analysis and sampling model. This model has so far identified 224 ducts to be inspected as a priority, out of the 5,000 unpiggable ducts in the Teréga network
- Design of a 10-year plan to inspect these ducts by excavation to enhance the model and the relevance of future inspections
- Participation in national and European working groups to identify potential other innovative duct inspection methods

Progress to date

- Analysis to establish the completeness and quality of current data (15% of ducts inspected under the 10-year plan)

- Ongoing incorporation of inspection results to improve the model
- Participation in the GRTgaz Open Innovation Challenge: 'Detection and quantification of non-visible metal pipelines defects'

Customer benefits

- Improved efficiency and optimised costs as a result of adapting inspection frequency
- Improved control of duct integrity

Future developments

- Analysis and comparison of excavation results with the current duct sampling campaign
- Testing of a new duct inspection technology, followed by its roll-out if the results are persuasive.

SAFETY IS ALSO INNOVATION!

Safety is a fundamental value for Teréga, well illustrated with the PARI 2025 initiative. Designed to involve all employees in an integrated commitment to safety, this initiative sets out effective accident and industrial risk prevention rules, through a simplified safety reference system, special training modules and new tools.

Including an infrastructure safety component, the "infrastructure integrity" program thus actively contributes to the company's ambitious 'Zero Accidents, Zero Snagging' objective targeted by 2025.



Insertion of a pipe into its concrete duct where it passes beneath a road.

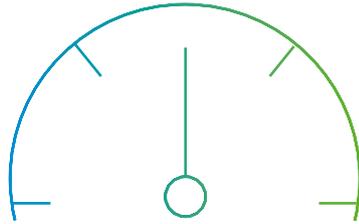


Repairing a gas pipe.

OPERATIONAL PERFORMANCE AND SAFETY

Improving network monitoring and maintenance means exploiting the capabilities of digital technology





As a high-profile gas industry stakeholder and infrastructure manager, Teréga has a clear responsibility to deliver **operational excellence in complete safety**. This essential and non-negotiable priority is central to the PARI 2025 Zero Accident, Zero Snagging initiative.

Its goal is clearly stated: to apply a constant process of innovation to guarantee continuity of supply through greater **agility, reliability and anticipation**.

R&I therefore plays an integral role in the commitment to deploy automated real-time monitoring of the network. The programme also aims to introduce **new digital** predictive maintenance and augmented reality systems that will enable operators to deliver continuous efficiency improvements at operational level. R&I is then eager to exploit the new opportunities presented by **big data architectures** and the broad range of applications of artificial intelligence. The applications of technology are expanding all the time: for example, data storage and processing capacity have exploded with the advent of cloud computing, while progress in telecoms and connected objects now allows to view the status of individual assets in real time.

Advances on this scale are clearly beneficial to business and customers alike.

“Operational performance and safety are essential drivers of improvement for a company like ours, having to constantly ensure the availability of its facilities, while they can be confronted with significant industrial risks anytime.”



Natacha Merlet

EI2A (Electricity, Instrumentation, Automation and Analysis)
Manager and R&I 'Operational Performance and Safety'
Programme Manager

▶ Three R&I projects that combine digital capabilities with network service

1 - Applying artificial intelligence to aerial monitoring



THE AIM

This R&I project applies the Teréga innovation strategy to improving and automating aerial monitoring of the network, which is currently carried out by fixed-wing aircraft or helicopter. The wider ambition of this project is to avoid the environmental risks posed by unregistered third-party work, urban development or land movement, for example.

The approach

- A range of different aerial monitoring techniques are being tested (vertical aerial photography from a fixed-wing aircraft, drone imagery and the use of satellite images)
- The use of artificial intelligence for image processing is being combined with a range of tested techniques to automate network monitoring

Progress to date

- Development of a threat detection system that compares new vertical aerial photographic images with previous surveys
- Launch of a technical and economic study to assess the feasibility of implementing a monitoring solution based on analysing satellite imagery

Customer benefits

- Optimised monitoring safety and reliability
- Traceability of anomalies (using an auditable system)
- Increased monitoring frequency

Future developments

- Improving vertical photographic image quality and georeferencing
- Increasing system reliability and rolling-out every stage of the automated acquisition and the processing of data
- Pursuing assessment of enhanced monitoring based on satellite image analysis



Aerial image of a gas pipeline.

PERFORMANCE IS ALSO ABOUT THE SAFETY OF PEOPLE

In addition to ensuring and monitoring the integrity of network structures, R&I focuses on the everyday priority of Teréga to ensure the safety of its operations staff, partners and local residents. R&I is fully committed to providing innovative solutions to achieve the ambition set for the PARI 2025 Zero Accidents, Zero Snagging initiative. A new R&I programme called 'People Safety' is designed to implement technologies to ensure safe man/machine interactions and bring forward solutions that eliminate the need for contact between operators' hands and pipelines.

2 - Detection of leaks, unregistered work or land movement using new-generation fibre optic technology

THE AIM

This R&I project confirms the Teréga commitment to developing a new and more efficient optical fibre technology better suited to its monitoring needs and infrastructure specifications. It follows on from an initial R&I assessment of the capabilities offered by optical fibres for real-time transmission of data reporting the condition of gas pipelines and their immediate surroundings.

The approach

- A new optical fibre technology to measure temperature, stress and vibration simultaneously is being developed and tested as part of a collaborative project involving TOTAL, SAIPEM and start-up Febus Optics
- Systems to detect pipeline external attacks or even potential leaks are also being assessed

Progress to date

- A state-of-the-art survey has been conducted to assess the best technologies currently available, identify the precise type of optical fibre to be used and identify all installation constraints
- Tests are being conducted on the Gascogne Midi Reinforcement (RGM) project site

Customer benefits

- Optimised cost development of a technology that provides improved remote detection of network activity in real time
- Faster response times for a higher level of service continuity

Future developments

- Construction of a test facility followed by the testing and development of the processing algorithm
- Definition of the roll-out and implementation strategy for an initial version of the operational system on a new engineered structure
- Definition of the data reporting strategy and data usage applications



Optical fibres installed in their ducts alongside a pipeline.



Optical fibres drawer at the Saint-Justin station.

3 - Using new data access solutions to improve equipment maintenance and service life

THE AIM

This R&I project demonstrates that ensuring the safety of on-site predictive maintenance operations is an ongoing concern at Teréga, as is installation safety. R&I aims to address these priorities by focusing on the introduction of new digital predictive maintenance tools and augmented reality solutions.

The approach

- Large volumes of compressor data are gathered and stored for processing and analysis by a machine learning system
- Special algorithms are used to acquire knowledge from the data analysed (identification of the causes of failures and identification

of the optimum maintenance intervals)

- Augmented reality applications are being tested to help field operators to prepare and carry out maintenance operations in complete safety.

Progress to date

- Finalisation of the failure prediction model for two compressors
- Production of the data display interface and enhancement of the model based on operator input
- The roll-out of augmented reality applications has been postponed as a result of priority being given to the field introduction of real-time scheduling and maintenance task management tools

Customer benefits

- Productivity gains
- Early-stage anticipation of equipment failures
- Improved safety of on-site operations

Future developments

- Finalisation of the failure prediction model for the two compressors, followed by its operational commissioning
- Extension of the predictive maintenance model to other equipment
- Redefinition of augmented reality case studies and launch of the first pilot applications

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GREENHOUSE GAS EMISSIONS CONTROLS
AND ENERGY EFFICIENCY

Positive environmental
performance means
avoiding, reducing,
offsetting
and innovating





As a **responsible company**, Teréga pays special attention to containing its environmental footprint. It is also committed to successfully meeting the challenges set out in the French Energy Transition for Green Growth Act (LTECV), which aims to **reduce greenhouse gas (GHG) emissions** to 40% lower than 1990's levels by 2030. For this purpose, R&I is focusing particularly on three priorities while maintaining the same level of service: the first is to develop a system to optimise operation of its compressors to **reduce energy costs**, the second is to bring forward innovative solutions for reducing overall Teréga GHG emissions, and the third is to eliminate energy losses through their recovering and recycling.

“As a company that has been ISO 50001 certified since 2014, Teréga has made energy efficiency one of its main concerns. This R&I and BE POSITIVE programme consolidates and intensifies this commitment.”



Éric Bouley

Processes Department Manager
and R&I 'Controlling our Greenhouse Gas Emissions
and Energy Efficiency' Programme Manager

▷ Two R&I projects to improve energy efficiency at Teréga

1 - Reducing emissions generated by transmission decompression



THE AIM

This project enables R&I to test a range of different technologies to limit and reduce the greenhouse gas (GHG) emissions generated by decompression actions needed prior to any work and/or maintenance operations on pipelines. Doing so will help Teréga to contain its environmental footprint sustainably.

The approach

- Testing different decompression techniques (classic venting method, reducing pressure via local consumption, using temporary connections, gas combustion or recompression for reuse)
- Developing a decision-making tool for operators to help them decide on the most appropriate method in each situation

Progress to date

- Purchase of a flare stack for deployment and use where appropriate
- Study and sizing of a mobile recompression unit tailored to Teréga's needs and operating conditions

Customer benefits

- The guarantee of a contractual relationship with a responsible operator committed to shrinking its environmental footprint by meeting and exceeding its legal GHG emission-reduction commitments

Future developments

- Manufacture of a mobile recompression truck, followed by operator testing and commissioning
- Research and studies for new GHG emission-reduction solutions

RECOVERING SMALL GAS LEAKS

A proportion of Teréga emissions are the result of leaks from compressor seals. Designed to provide an effective seal for rotating parts, it is inevitable that these components should release small quantities of gas. These losses are estimated at approximately 5% of all Teréga GHG emissions. So a new R&I project has been initiated to design, size, build and operate an SRGG system (seal gas recovery system) to recover and recycle these losses. This system collects the escaped gases and re-compresses them for reinjection into the network.



Compressor at Sauveterre-de-Guyenne.

2 - Optimising compressor stations operation

THE AIM

Teréga compressor fleet requests high operating costs. Gas compressor stations also represent 30% of Teréga CO₂ equivalent emissions. Because each compressor has its own characteristics, the project aims to suggest the best usage scenarios so that the compressor fleet can function more effectively (with reduced wastage and emissions). There is currently no tool on the market that can do this.

The approach

- An integrated simulation tool is under development to optimise compressor fleet operation based on the full range of gas supply flows
- Future situations and changes to the network are now anticipated and simulated upfront

Progress to date

- Development of the application and launch of the initial tests to validated the correct running of the algorithm
- Creation of a user-friendly visual interface for optimum operator acceptance and familiarisation

Customer benefits

- Rationalised operation of the compressor fleet for optimised energy usage and reduced operating expenses

Future developments

- Application implementation
- Forward development towards machine learning and systematic optimisation based on the required flow scenarios



Map of the Teréga network showing compressor stations.

AVOID-REDUCE-OFFSET

Teréga's environmental policy is guided by three principles: Avoid-Reduce-Offset. Convergence of the R&I energy efficiency and regional integration programmes is uniting Teréga teams around its ambitious BE POSITIVE goal:

to achieve neutral environmental performance for Teréga in 2020, and positive environmental performance by 2025! As a company that leads by example, Teréga takes a proactive attitude to AVOIDING greenhouse gas

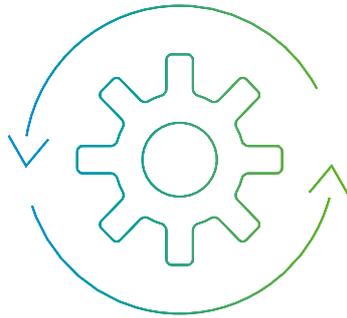
emissions, REDUCING its carbon footprint through energy optimisation and OFFSETTING its residual impacts on the environment and biodiversity.



NETWORK AND SMART GRID INTEGRATION

Accelerating the energy transition means preparing for the future... today





Teréga is demonstrating its commitment to **accelerating the energy transition** by pursuing its initiatives to secure and promote the role of gas in tomorrow's energy mix. Therefore, R&I has a logical role to play in **network and Smart Grid integration**, since both are cross-functional issues central to the energy transition, which will inevitably result in a higher level of complementarity between energy sources.

Gas networks are at the heart of this new paradigm, and will play a central role in **balancing energy demand**. So R&I is continuing to expand its knowledge in areas consistent with achieving the strategic ambitions of the IMPACTS 2025 corporate plan. Teréga's involvement in the JUPITER 1000 project and its expertise in **Power-to-Gas** will be extended with a more extensive project on smart multi-energy systems.

“Energy sources can no longer be considered in silos. Energy systems must be considered in their entirety if we are to recover and reuse losses and optimise end-user consumption. The gas network has a key role to play in these systems.”

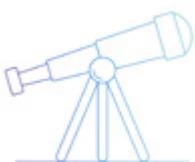


William Rahain

Business Opportunities Research Manager
and R&I 'Network and Smart Grids Integration'
Programme Manager

▶ An R&I project that prepares the way for the future of gas

I - Making an active contribution to JUPITER 1000, France's first Power-to-Gas demonstrator



THE AIM

This R&I project underlines the commitment of Teréga and a number of its partners, including GRTgaz, to demonstrate the ability of gas infrastructures to balance the electricity grids by developing Power-to-Gas technology. The JUPITER 1000 project is designed to study the conversion of surplus renewable electricity first into green hydrogen (by electrolysis of water) and then into methane syngas (methanation reaction) by combining it with CO₂ captured from industrial flue gases. In this way, R&I is also anticipating future developments around the injection of new gases into natural gas transmission networks, thereby contributing to its 'decarbonisation'.

The approach

- Acquisition of skills across the full range of technical and operational issues related to Power-to-Gas
- Determining conditions that favour the injection of hydrogen and methane syngas
- Studying the viability of the Power-to-Gas financial model, its regulatory context and the smart management of the entire system

Progress to date

- Work initiated with civil engineering, pipelines and building
- Delivery of the first items of equipment (particularly for the electrolysis building block)
- Manufacturing of the methanation reactor and tests with different catalysts
- Launch of the technical and economic study

Customer benefits

- Maximised integration of renewable energies and recovery of surplus electricity for reuse
- Guaranteed security, quality and continuity of supply of new energies
- Early-stage readiness for requests from future customers

Future developments

- Delivery of the latest equipment and commissioning of the various technology building blocks (electrolysis, CO₂ capture, methanation, etc.)
- Tests, trials, analyses and publication of results
- Finalisation of the study and demonstration of the technical and financial viability of the Power-to-Gas solution



Electrolyser.



Aerial view of the demonstrator site.

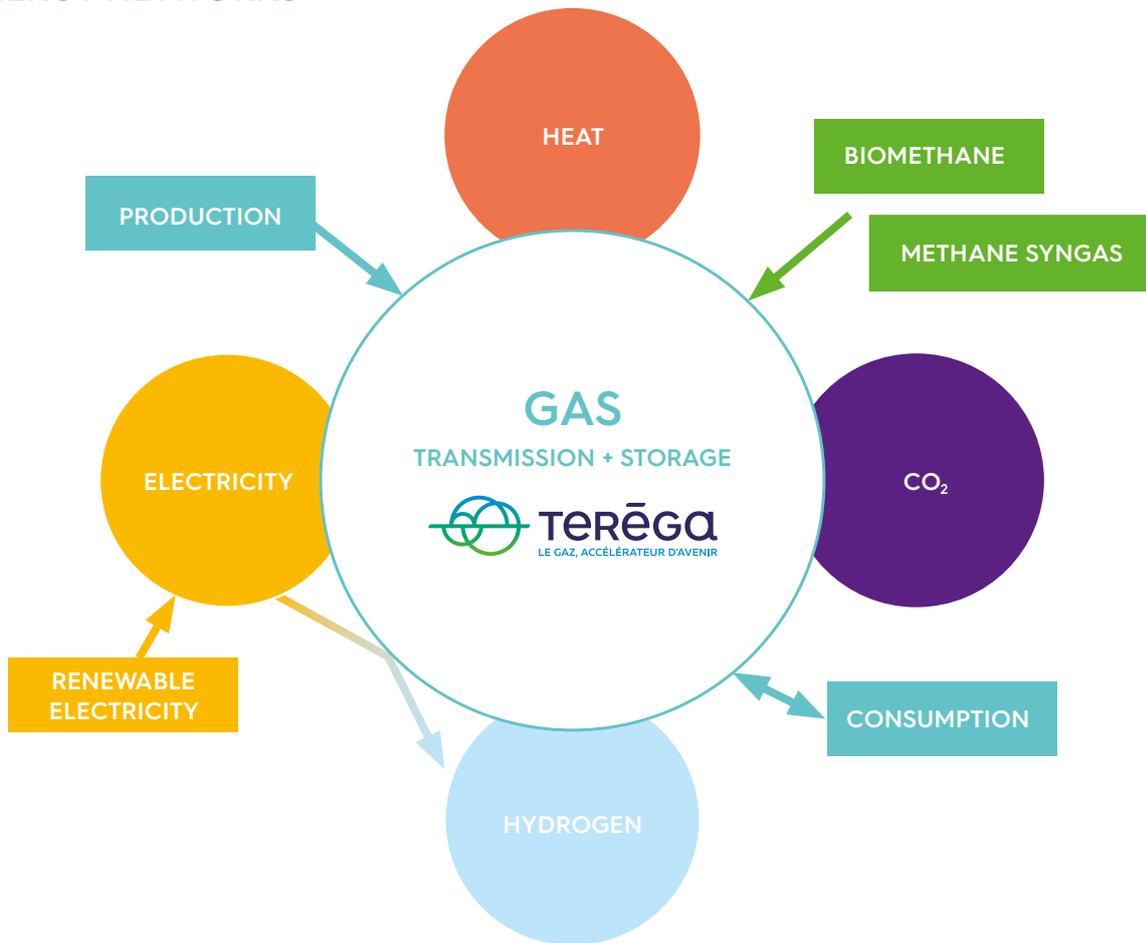
Project supported by:



The project partners:



TERÉGA INFRASTRUCTURES AT THE HEART OF ENERGY NETWORKS



IMPULSE 2025: DEVELOPING A VISION OF SMART MULTI-ENERGY GRIDS

As the number of renewable energy sources (gas, electricity and heat) increases, a revolution is needed to create new synergies. Until now, energy sources have been treated in silos and independently, with little or no joined-up thinking. The development of digital technologies and decentralised energy generation is driving a need for structural changes in order to create tomorrow's energy system. In future, energies will be increasingly interconnected and interlinked, which implies a paradigm shift in which distinct systems become a single package of energy: the Smart Multi-Energy Grid concept.

This holistic approach inevitably requires the involvement of all stakeholders (generators and consumers), energy sources and energy carriers.

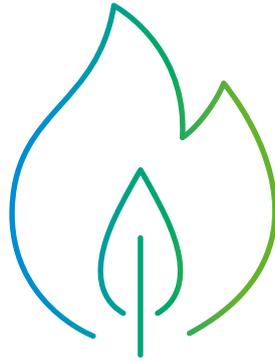
With Power-to-Gas and demonstrators like JUPITER 1000, Teréga is already actively considering the interconnection of electricity and gas supply networks. Its aim is now to go further still by leveraging smart digital network technologies considering all energy networks and any recoverable energy sources that may be available as the basis with the aim of rolling out new energy storage solutions and network interconnection

pathways. This ability would optimise overall energy, financial and environmental performance. R&I is willing to achieve this ambition through its IMPULSE 2025 project (Innovating and Mobilising to Unite Energy Systems). It sets out to demonstrate that the flexibility, adaptability and storage capacities of Teréga infrastructures make the company and the gas it supplies a central link in these Smart Multi-Energy Grids of the future.

NEW GASES

Facilitating their integration is all about anticipating change and working today on the energy mix of tomorrow





Teréga firmly believes **gas to be an energy of the future** having to play a key role in the energy transition. This is why the company continues to drive initiatives that promote and facilitate the integration of new gases. Indeed the energy transition will inevitably result in more of these gases being injected into existing gas supply networks through techniques such as **methanisation, Power-to-Gas, pyro-gasification and methanation**. For example, R&I is studying the composition of biomethanes, methane syngas and the acceptable level of hydrogen content when blended with natural gas to assess their **compatibility with installations** prior to promoting their injection into the supply system. Future challenges include anticipating the issues surrounding security, quality and continuity of gas supply. R&I teams are also actively contributing to **collaborative projects to evaluate a range of different methanation processes** to ensure high gas quality and position itself as an accelerator for growth in this sector.

“We want to be proactive in the development of new technologies for renewable gas sectors. This is one of our priority commitments, not only in terms of innovation, but also in terms of our corporate plan.”



Guilhem Caumette

Environment Engineer, Energy Research
and R&I New Gases Programme Manager

▷ Two R&I projects to facilitate the integration of renewable gases

1 - Researching the impacts of biomethane and hydrogen injection on existing installations



THE AIM

This R&I project continues the work already done by Teréga on anticipating developments around the injection of new gases into existing gas infrastructures by focusing on impact analyses and anticipating the issues of security, quality and continuity of supply.

The approach

- Measurement campaigns are conducted at biomethane injection sites to gain a better understanding of the composition and trace compounds content of biomethane, compared with natural gas
- Sampling methods and analysis techniques are under development

- Laboratory studies and tests are conducted to identify an acceptable level of hydrogen and biomethane for blending with natural gas to ensure zero impact on infrastructures
- Injection constraints are defined and shared with other European gas operators and the European Committee for Standardisation to ensure a shared industry-wide vision and anticipate any future standardisation process

Progress to date

- Since 2016, 59 measurement campaigns have been conducted at biomethane injection sites to gain a better understanding of the composition of these gases
- Corrosion indicators have been installed at Teréga biomethane injection sites, and analytical protocols have been defined
- A three-year thesis focused on analysing and characterising the trace compounds present in biogas and biomethane has just begun
- Recommendations have been

published of injecting hydrogen at different rates on natural gas transmission and distribution networks

Customer benefits

- Improved integration of renewable gases by anticipating the potential operational constraints resulting from their injection
- Early-stage readiness for requests from future customers

Future developments

- Continuation of measurement campaigns
- Corrosion analysis on the first indicators installed at Teréga's biomethane injection sites
- Continuation of the thesis with the development of a high-pressure sampling test bench and special analytical techniques
- Continuation of studies to assess the impact of hydrogen on end-users
- Tests to assess the weakening of welds in the presence of hydrogen (these tests complement those conducted on pipes by GRTgaz and the CEA)



The BioVilleneuvois facility in Villeneuve-sur-Lot operated by Fonroche.



The Méthalayou facility in Préchacq-Navarrenx set up by local farmers.

2 - Accelerating development of the methanation sector

THE AIM

This R&I project underlines Teréga's commitment to promoting the attractiveness of the renewable gases sector by studying a range of methanation processes in conjunction with start-ups, public-sector R&D laboratories, universities and other industry stakeholders. By optimising CO₂ recovery from other processes (such as methanisation, for example), methanation can double the efficiency and yield of biomethane production.

The approach

- The contribution made by gas operators to the Smart Grids of the future is facilitated through the emergence of innovative projects related to new gases
- The quality of gases injected or injectable into supply networks is assured by Teréga as a result of sharing its expertise and upskilling its own in-house teams
- The SOLIDIA experimental facility hosts pilot projects that test biogas enrichment by biological methanation in an operational environment

- The technical feasibility of producing methane syngas using innovative processes is being researched

Progress to date

- Preparation of the general implementation plan for the SOLIDIA platform, submission of applications for subsidies and establishment of the governance contract with all involved partners
- Launching of partnership-based projects to develop new methanation technologies

Customer benefits

- Promotion of new gas injection into the transmission system
- Optimisation of biomethane production by developing solutions for recovering CO₂ by methanation

Future developments

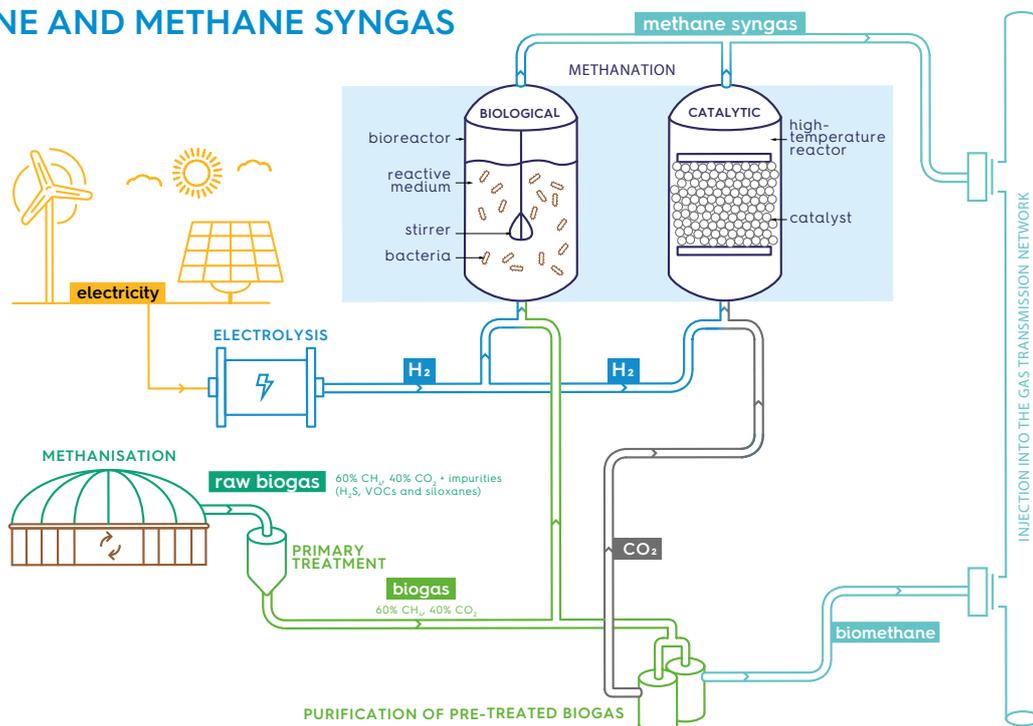
- Construction of the SOLIDIA facility, design of the pilot projects and qualification of process performance
- Launch of laboratory tests to qualify the performance of biological methanation for the enrichment of landfill gas or gas from pyro-gasification

- Continuation of partnership projects and technical and economic qualification of the innovative processes studied

GOING FURTHER... THE MARS PROJECT

Teréga is a contributor to the MARS (Renewable Solar Methane) project. Conducted jointly with the University of Paris Diderot and two gas operators (GRTgaz and GRDF) this laboratory research project focuses on the conversion of carbon dioxide (CO₂) to methane (CH₄) using sunlight and catalysts. This project could eventually offer a potential solution for recycling carbon dioxide into methane, while storing solar energy in the process.

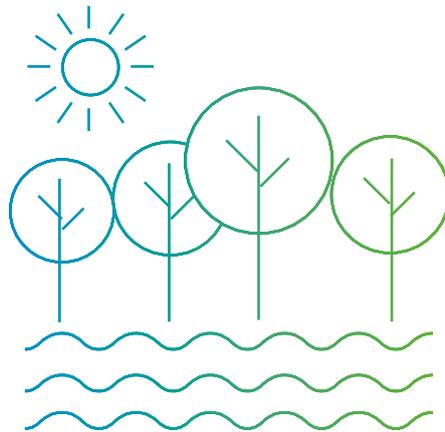
BIOMETHANE AND METHANE SYNGAS



LOCAL INTEGRATION
& ENVIRONMENTAL FOOTPRINT

Leading by example
means protecting
biodiversity, water
quality and
the landscape





Teréga is keen to demonstrate its **environmental commitment** at every level in its organisational structure. The purpose of this R&I programme is **to integrate its activities more effectively at local level**, promote their social acceptability and limit their environmental impacts. R&I teams have set four major ambitions for this programme: to develop measures that reduce impacts during the construction phase, to establish Teréga as the benchmark for environmental impact controls, to consider easements as potential reservoirs of biodiversity, and to put in place effective and innovative resources that facilitate public acceptance of Teréga operations and projects.

“R&I aims to improve the local integration of infrastructures and limiting their environmental impact. The programme therefore incorporates several projects directly related to the BE POSITIVE initiative.”



Laëtitia Mahenc

Head of the Environment & CSR Department,
R&I Local Integration and Environmental Footprint
Programme Manager and BE POSITIVE Programme Manager

▷ Two R&I projects to protect the environment and biodiversity

1 - Improving biodiversity through a clearer understanding of the contribution made by linear infrastructures

THE AIM

This R&I project reflects the Teréga's willingness to optimise its operations to avoid compromising biodiversity and, wherever possible, to promote it. So Teréga has made its industrial resources available for this project and, since 2014, has been co-funding the ITTECOP programme¹ initiated with encouragement from the French Ministry for Ecological and Solidarity Transition and ADEME (the French Environment and Energy Management Agency). The outcome from ITTECOP programme will guide Teréga to determine the best routes for its future projects and improve its easement management practices. Teréga is also an active contributor to the development of a method for the rapid assessment of ecological offsets.

THE MERCIe METHOD IN GREATER DETAIL

Ensuring maximum compliance with Teréga's ecological commitments means developing the most objective method possible for evaluating the offsets implemented after on-site project completion. For this purpose, R&I has worked with the University of Montpellier to develop the MERCIe methodology. This method adopts a very operational approach to comparing the ecological losses resulting from an infrastructure project with the gains delivered by the offsets implemented. It then assesses the status of an area across its 'entire ecosystem', rather than focusing its analysis solely on certain species or categories (protected species, etc.). This methodology provides a more standardised basis for offsetting, and is applicable to business activities other than those of Teréga.

The approach

- The linear infrastructure offset strategy, the potential of easements for pollination and the mutual impact on biodiversity of the green areas around operational sites are three issues addressed by this programme
- The ecological losses caused by a development project and the gains delivered by offsetting are assessed objectively using the MERCIe methodology



Snakes head fritillary.

Progress to date

- Publication of the PolLinéaire project fact sheet recommending that green areas around operational sites should be integrated into existing ecological networks, such as green and blue corridors
- Incorporation of the data from the Gascogne Midi Reinforcement (RGM) project site into consolidation of the MERCIe evaluation method

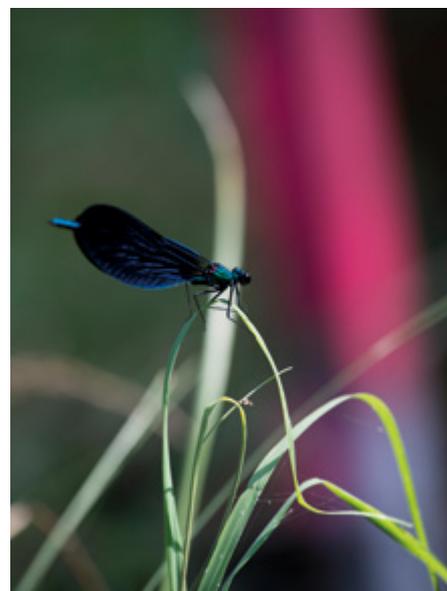
Customer benefits

- The opportunity to exercise responsibility in purchasing by choosing Teréga as a gas transport operator committed to protecting biodiversity
- Development of more responsible - and therefore more 'acceptable' - projects, as a result of standardising the determination of offsetting measures.

Future developments

- Extension of the MERCIe methodology testing programme to include other Teréga projects.

1 - Land Transport Infrastructures, Ecosystems and the Landscape



The Beautiful Demoiselle damselfly (*Calopteryx virgo*).

2 - Adapting and implementing impact reduction methods during the on-site and/or operational phases



THE AIM

The aim of this R&I project is to develop an effective response to a real challenge by working on projects intended to improve Teréga on-site working practices. It addresses two priorities: conserving the environment and biodiversity and reducing the amount of waste generated.

The approach

- Priority is given to developing and qualifying efficient new technologies for filtering water on worksites
- Another important aspect of this project is to identify the best techniques available for replacing sandblasting as a means of paint stripping
- It also addresses the commitment to eliminate the use of plant protection products at delivery points

Progress to date

- Testing of a new solution for filtering water on worksites, which uses a Geotube membrane to avoid and mitigate the effects of discharging excessive volumes of suspended matter into the natural environment
- Seeking alternative solutions to avoid the use of plant protection products

Customer benefits

- The opportunity to exercise responsibility in purchasing by opting for Teréga and its expertise in biodiversity conservation, water management and environmental footprint reduction
- Guaranteed continuity of service as a direct result of reliability gains that meet regulatory controls

Future developments

- Roll-out of new solutions in the event of persuasive test results. Where results are not persuasive, further research and qualification to identify other alternative techniques
- Identification of new application scenarios to reduce impacts during the on-site and/or operational phases, followed by identification of solutions and testing.

SOCIAL ACCEPTABILITY

Teréga has set itself the ambition of identifying new effective and innovative ways to promote public acceptance of its business activities and projects. More specifically, the company is developing and validating best practices that effectively address the challenges posed by the energy transition and the new activities that accompany it. Its goal is to raise public awareness of its mission and the work it does as an energy provider through information, events and networking initiatives that bring local managers together with R&I and the Sales Department, for example.



Easement above a marked Teréga pipeline.

GLOSSARY



Electrolysis

The process used to convert electrical energy into chemical energy. Electrolysis of water is used to produce hydrogen.

Epoxy coating

Epoxy is a material with high mechanical strength and chemical resistance used in the manufacture of pipes. This type of coating reduces the risk of corrosion damage and prevents the infiltration of external pollutants.

Machine learning

A technology based on artificial intelligence that enables computers to learn automatically and make statistical predictions from a given set of data.

Magnetic tomography

A contactless pipeline inspection technology that can detect wall and weld defects, corrosion, cracks, physical characteristics, alignment and below-ground depth.

Methanation

A biological or catalytic industrial process in which carbon dioxide or carbon monoxide reacts with hydrogen to produce water and methane. This type of methane is referred to as methane syngas.

Non-piggable pipeline

An underground pipeline through which it is not possible to send cleaning or inspection devices.

Power-to-Gas

An industrial process in which surplus electricity generated from renewable energy sources is converted into hydrogen gas by electrolysis. This hydrogen can either be injected directly into the natural gas network at a controlled rate or converted by methanation into methane syngas by combining it with carbon dioxide captured elsewhere.

Pressure reduction via local consumption

The valves are closed upstream and downstream of the working area without interrupting customer supplies. Gas pressure therefore gradually decreases until it reaches a residual basic level.

Pyro-gasification

This high-temperature process thermally converts dry organic matter into syngas in the presence of a small amount of oxygen.

Trace compounds

Compounds that are present in gas in very low concentrations, but which nevertheless pose potential risks to Teréga operations.

Venting

The atmospheric release or expansion of gas from a pressurised structure in order to make it available for remedial work or maintenance.

TERÉGA would like to thank CRE for its support on R&I activities, which is enabling the company to prepare effectively for the future of gas transport networks.

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