natran R&I

2024

ACTIVITY REPORT

Research
& Innovation

Contents

« NaTran R&I: writing the future of renewable gas transmission »

Pierre Blouet
Director of NaTran R&I

Accompanied by a new name NaTran and new strapline – Le cœur de vos énergies (At the heart of your energies) –, our 20th anniversary is an opportunity to start a new chapter in our history. Two of our entities are impacted by the rebrand: GRTgaz has become NaTran and our research centre RICE is now NaTran R&I, to fully embrace our new identity.

Our name, NaTran R&I, proclaims our company's core business: conducting research and innovation to support NaTran, a transmission system operator for all gases, in helping France meet its decarbonisation targets (biomethane, hydrogen, CO_2) and guaranteeing the energy sovereignty of France and Europe as a whole. The name also underscores our transformation and our societal commitment to protecting nature and promoting the energy transition.

Our strapline – At the heart of your energies – emphasises our central role in the French and European gas and energy system and reflects our commitment to the public interest and all of its stakeholders.

We are on a clear heading: to lead the research and innovation efforts to enable NaTran to become a benchmark European transport and logistics operator for renewable and low-carbon gases, as well as hydrogen and CO_2.

To this end, NaTran is committed to pursuing an ambitious business strategy which aims to achieve carbon neutrality by 2050, with a first major milestone set for 2030. The NaTran2030 project aims to:

- make at least 50% green investments by 2030;
- increase fivefold the volume of renewable gas injected into our networks;
- develop the first open hydrogen and CO_2 infrastructure in France;
- reduce our carbon footprint by 40%;
- attract and develop the skills needed to support our transformation.

With all this in mind, our five R&I programs are going to be all the more crucial to help NaTran navigate its corporate project and, more broadly, to support all of our gas supply infrastructure customers and beyond along the path to decarbonisation and industrial efficiency.

Under the name NaTran, we look forward to opening a new chapter in our history, drawing on the expertise of our employees and in close collaboration with our stakeholders, while continuing our long and deeply rooted tradition of promoting technological excellence, safety, efficiency and commitment to the public interest.

Editorial

92
biomethane sites injecting gas into the NaTran network with a total capacity of 2.8 TWh/year

588 TWh
of natural gas transported in 2024

90
families of inventions representing 375 patent titles and applications in gas transmission, storage and distribution, validated in 36 countries.

natran R&I

Our missions: designing, managing and carrying out Research & Innovation (R&I) projects for NaTran and/or external customers, mainly gas infrastructure operators.
In this role, we ensure the consistency of R&I activities in line with the objectives of the corporate project, serve as a source of recommendations for NaTran R&I policies, listen to the business unit managers and inform their decision-making, coordinate NaTran's R&I activities and provide monitoring and reporting on them.

natran

NaTran is the new name of GRTgaz. To mark 20 years in business, in 2025 the company is starting a new chapter in its history by changing its name and steering its corporate project NaTran2030 to focus on driving the energy transition and achieving carbon neutrality by 2050. To reach its goals, the company is adapting its network and its practices to the evolving environmental, economic and digital landscapes. It offers infrastructure and a logistics system adapted to the gases underpinning the energy transition (biomethane, H_2 and CO_2). NaTran is Europe's second-largest gas transmission system operator. NaTran fulfils a public service mission, ensuring the safety of gas transmission for all its customers.

€43.5M
R&I budget

10
theses in progress including 4 CIFRE theses

3,334
employees

28
test benches

4
R&I sites (Villeneuve-La-Garenne, Alfortville and Fos-sur-Mer for Jupiter 1000, Immeuble Cityzen in Bois-Colombes)

33,795 KM
incl. 32,634 km in France

70
innovation projects supported

40
international customers

€2,090M
in turnover

NaTran is a European leader in gas transmission and a world expert in gas systems.

116
doctors, researchers and technicians

NaTran R&I is the research centre set up by NaTran on 31/12/2017.

5 RESEARCH PROGRAMS FOR SUSTAINABLE ENERGY INFRASTRUCTURE

2024 was a year marked by an acceleration of the development of NaTran R&I, a leading European player in research and innovation for energy infrastructure. Firmly established at the forefront of technological advances, we have strengthened our teams and testing capabilities to develop high-value solutions that address the major challenges our industry is facing.

Tanguy Manchec
Chief R&I Officer at NaTran and Head of the 5 programs

5 strategic priorities supported

Our research focuses on five strategic priorities designed to inform our partners, overcome technological barriers and deploy value-creating innovations:

OPTISE: optimising the functioning, operation and safety of the gas system;

IMPACT: reducing the environmental impact of the gas supply chain;

NEW CH_4: preparing the networks for the arrival of renewable methanes;

PREPARE: energy forecasting, network control and optimisation;

H_2 & CO_2: preparing the networks for the arrival of hydrogen and CO_2.

Strong growth for OPTISE and IMPACT

In 2024, two areas stood out for their exceptional growth:

- **Within the OPTISE program, predictive maintenance powered by artificial intelligence (AI):** by integrating advanced machine learning models, we are revolutionising our maintenance practices, shifting from systematic programs to increasingly targeted predictive maintenance actions. The performance of these AI tools has increased exponentially in recent years, improving the reliability and efficiency of critical infrastructure.
- **Within the IMPACT program, the reduction of environmental impacts:** in 2024 we launched an ambitious new roadmap to measure and preserve biodiversity on our industrial sites and along our pipelines.

At the same time, we are developing granular quantification models for methane emissions, deployed on key gas supply chain installations such as storage facilities, LNG terminals and compressor stations. These initiatives have positioned NaTran R&I as a global benchmark, as evidenced by the latest report published by the United Nations *International Methane Emissions Observatory* (IMEO).

By drawing on robust expertise and cutting-edge technologies developed in our five research programs, we reaffirm our mission to **support the global energy transition while ensuring a sustainable future for the next generations.**

NATRAN MANAGES R&I FOR EVERY LINK IN THE VALUE CHAIN

01 STATE OF THE ART

Conducting a comprehensive and in-depth examination of existing literature, knowledge and practices.

02 GAP ANALYSIS

Using state-of-the-art techniques, identifying residual technological barriers in order to meet the industrial and environmental challenges our customers face.

03 R&I ROADMAP

Preparing a strategy document describing long-term objectives, intermediate steps and specific actions to guide R&I activities, thereby promoting the growth of knowledge.

04 PARTNERSHIPS

Securing collaborations between two or more entities (businesses, academic institutions, government organisations, etc.) to carry out joint research and development activities.

05 FUNDING

Identifying public and private funding to cover the research budgets, particularly from national and European agencies.

06 PERFORMANCE

Carrying out research work defined in the roadmap, by the creation of value.

07 DISTRIBUTION

Sharing and communicating results, knowledge and progress achieved through R&I activities in order to promote deployment and operational implementation within the sector.

DRIVING TRANSFORMATION THROUGH INNOVATION

The priority of our Innovation team for 2025–2030 is clear: to strengthen the impact of innovation on NaTran's transformation by generating value and performance. This will be done by taking a proactive approach underpinned by intelligence, experimentation and an open ecosystem.

Our goal is to make innovation a key driver of our company's transformation.
This will be attained through two main objectives: the sustainable improvement of our economic and environmental performance, and the development of our business.

Achieving these objectives will require a profound cultural transformation.

Our Innovation team.

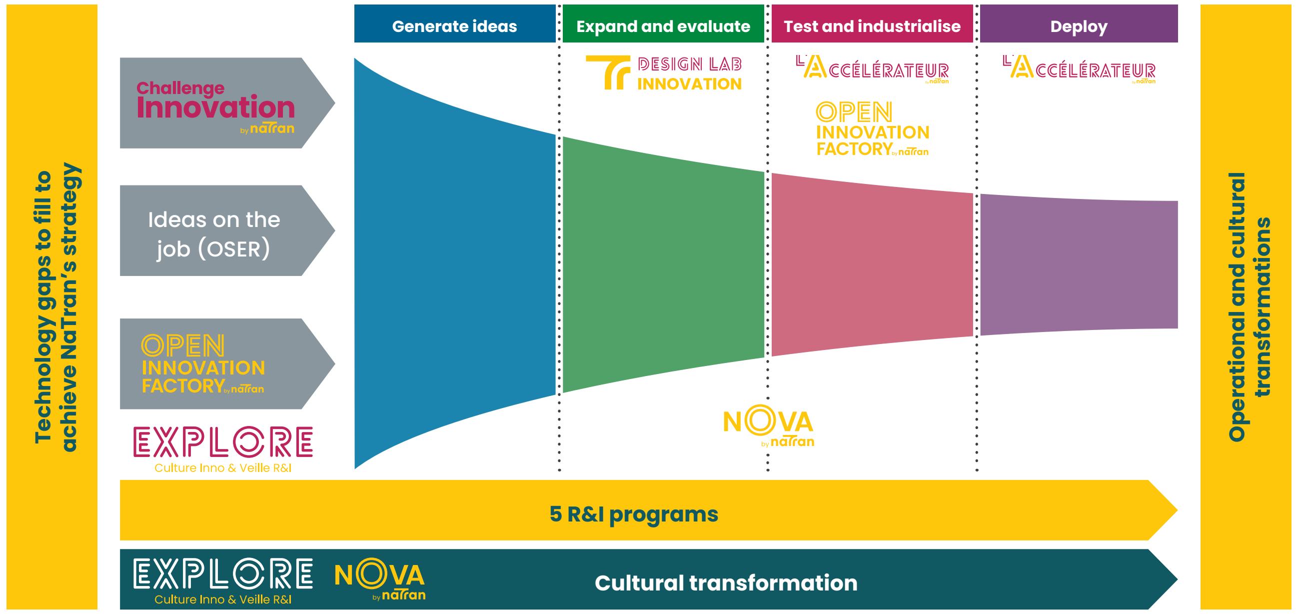
Identify, experiment, deploy

Our innovation activities have thus focused on identifying, experimenting and accelerating the deployment of value-creating projects, whether they come from our internal innovation challenge, on-site initiatives or strategic intelligence.

We have stepped up our partnerships with start-ups and innovators through our Nova incubator, our *Open Innovation* calls for projects and the framework we created for benchmarking best gas supply infrastructure practices among European transmission system operators: the TSO Innovation Club.

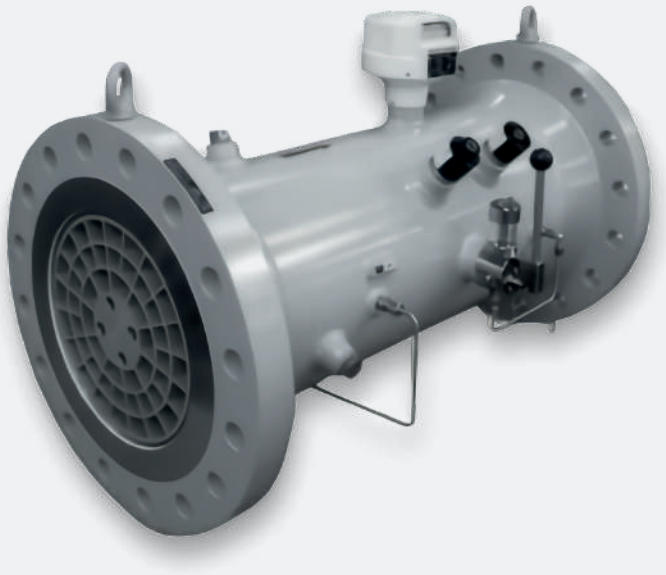
Our proactive, outward-looking approach based on experimentation and dynamic monitoring in the interests of concrete business objectives, aims to establish NaTran as a standard-setter and visionary player in renewable gas transmission for a long time to come.

THE INNOVATION MANAGEMENT PROCESS AT NATRAN



A focus on two examples of technological and managerial innovation from the multiple innovations tested and deployed in 2024.

SeADvance



SeAdvance: predicting unplanned failures of electromechanical equipment

SeAdvance, a winning start-up at the Nova 2024 incubator, is developing a predictive AI solution to predict equipment failures by leveraging historical maintenance and operation data. Its model, used on NaTran gas meters, detected 95% of non-conformities with a very small drift error. This tool will further improve the accuracy of metering systems installed on producers' injection plants and gas consumers' delivery stations.

The model developed by SeAdvance was used to exploit the data available on NaTran gas meters to predict accuracy drift and adjust the maintenance program.

Transformation: promoting *soft skills*

The development of skills and behaviours that benefit our company is a key factor in the success of our transformation.
Key Behaviour Indicators (KBIs) are an objective measure of *soft skills* in their work environment, complementing traditional KPIs.

A 2024 experiment showed that innovation has a strong impact on behaviours such as cross-functional collaboration, collective intelligence, simplification, task prioritisation and acquisition of new project management methods. Nearly 60% of employees say some of their *soft skills* have changed in a lasting way thanks to innovation programs.

INNOVATION-DRIVEN SKILLS AND BEHAVIOURS ASSESSED

Skill
TAKE ACTION

Entrepreneurial spirit
Initiative

Skill
COMMUNICATE & COLLABORATE

Open-mindedness
Knowledge transfer

Skill
WORKPLACE ENVIRONMENT PERCEPTION

Organisational culture
Right to make mistakes
Cohesion
Recognition

5 COMPLEMENTARY INNOVATION SCHEMES AND A START-UPS INCUBATOR

Our five innovation schemes are cornerstones for the testing and deployment of our innovation projects, in synergy with the R&I programs and in support of NaTran's strategic goals. Their added value is measured through *Key Performance Indicators* (KPIs) and *Key Behaviour Indicators* (KBIs), expressing the economic impact, energy transition and cultural transformation that they drive.

Challenge Innovation by natran

Identifying,

promoting and supporting the deployment of employees' most promising initiatives through an annual program

- LAUNCH OF THEMATIC CHALLENGES BY DEPARTMENT
- ORGANISATION OF AN ANNUAL INNOVATION PROGRAM FOR EMPLOYEES
- TEAM SUPPORT

EXPLORE
Culture Inno & Veille R&I

Promoting

a culture of innovation company-wide and sharing new trends in the external ecosystem (technical, organisational, market, start-ups, etc.)

- ORGANISATION OF INNOVATION GROUPS
- R&I INTELLIGENCE

DESIGN LAB INNOVATION

Supporting

the upstream exploration and design phases of innovation schemes with collaborative innovation methods

- DESIGN PROSPECTIF
- DESIGN OPÉRATIONNEL
- DESIGN DE SERVICES
- DESIGN D'IMPACT
- DESIGN STRATÉGIQUE

OPEN INNOVATION FACTORY by natran

Solving

internal business problems by partnering with innovation ecosystems and monitoring the success of projects

- CALLS FOR PROJECTS
- START-UP SOURCING
- CONTRACTUALISATION
- PROJECT MONITORING
- WINNERS NETWORK COORDINATION

L'ACCÉLÉRATEUR by natran

Accelerating

high-stakes innovation through an adapted service offer to take it to the next level and allow projects to come to fruition more quickly

- MASTER PLAN WORKSHOPS
- EXTERNAL PROMOTION
- INTELLECTUAL PROPERTY
- BUSINESS MODEL AND DE-RISKING
- TESTING AND INDUSTRIALISATION SUPPORT

NOVA by natran

Incubating

start-ups in the energy transition field, with a service including five key benefits:

- TESTING ON OUR USE CASES
- SUPPORT FROM OUR EXPERTS
- ACCESS TO OUR LABORATORY TESTING FACILITIES
- ACCESS TO OUR WORK SPACES IN THE PARIS REGION
- INTRODUCTION TO INVESTMENT FUNDS

INNOVATION PROJECTS

ECONOMIC EFFICIENCY | ENERGY TRANSITION | CULTURAL TRANSFORMATION

BRINGING AN INTERNATIONAL DIMENSION THROUGH OUR CUSTOMERS AND PARTNERS

FRANCE
Institutional and academic partners

ADEME, advancity, anr, axelera, bpifrance, cnrs, ESPCI, FONCSI, INERIS, MINES ParisTech, Tenerrdis

EUROPE
Energy infrastructure operators

creos, elengy, enagas, fluxys, GRDF, R-GDS, RÉGAZ BORDEAUX, Rte, SNAM, Sorégies Groupe, storengy, SWISSGAS, TERÉGA, Transitgas AG

EUROPE
Industrial groups

Air Liquide, COLAS, DISTRAN SWITZERLAND, EDF, GE, SALINS, suez, TotalEnergies

EUROPE
Institutional partners

horizon europe, Hydrogen Europe

EUROPE
R&I associations

cen, EPRG, GERG

EUROPE
R&I centres

cea, evida, tecnalia, TNO

NORTH AMERICA
Transmission/ distribution network operators

énergir, PG&E, SoCalGas

NORTH AMERICA
R&I associations

PRCI

NORTH AMERICA
R&I centres

GTI ENERGY, NYSEARCH

SOUTH AMERICA
Transmission/ distribution infrastructure operators

comgas, TAG

2024 HIGHLIGHTS

JANUARY

The second cohort of our Nova incubator was selected by a jury composed of representatives of NaTran R&I and the investment fund UI-Investissements: the four start-ups (Mirega, Revcoo, Safehear, SeAdvance) won a one-year mentoring program in the Nova incubator.

Nova attended the launch meeting of the COREu project *(CO_2 Routes across Europe)* in Trondheim, Norway, the largest Horizon Europe-funded research project in the field of carbon capture and storage. Objective: establish an efficient cross-border network connecting major CO_2 emitters to storage sites across Europe.

COREu

FEBRUARY

The **PilgrHYm project launch meeting** was held at our offices. This pre-normative research project funded by the European Union under the *Clean Hydrogen Partnership* aims to develop protocols and guidelines to repurpose existing gas pipelines for the transmission of hydrogen.

MARCH

FrHyGe
Underground Hydrogen Storage

Official launch of the FrHyGE project, supported and subsidised by the European Union under the *Clean Hydrogen Partnership*, to validate underground hydrogen storage in saline cavities on an industrial scale.
It will set up a demonstrator at the Storengy underground storage site in Manosque and study the replicability of this technology at the Harsefeld site in Germany and more broadly at European level.

APRIL

A concept and design space was inaugurated for the La Forge network in Bois-Colombes, aimed at promoting and democratising prototyping through collaboration, spearheaded by a group of dedicated employees – Les artisans du Faire.
The activities and demonstrations showcased the benefits of reuse (#MadeInNaTran), with all the furniture in the space second hand.
This new concept will be deployed in the fablabs at our sites.

MAY

2024 edition of the *RICE for Tomorrow* event, an annual one-day meetup launched in 2022 to talk about the role and contributions of R&I. More than 50 people from 30 French and European companies attended the meeting in Alfortville. The program included plenary presentations and visits to testing facilities, including the FenHYx platform. The 2025 event is set to be bigger this year to welcome our international customers and partners.

Our teams attended the International Gas Research Conference 2024, a global gas research event held every three years, on 14-16 May in Banff, Canada: eight presentations in five sessions, moderation of two sessions and nine posters – three in partnerships – highlighted the diversity and relevance of our technical and scientific expertise.

JUNE

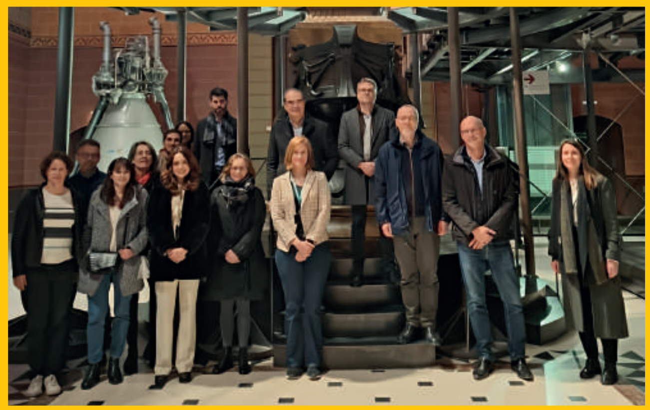
Launch of the first innovation club for European TSOs at the Palais du Luxembourg, attended by Vanina Paoli-Gagin, Senator of Aube and author of a report on innovation financing, along with seven TSOs: ENAGAS, Fluxys, Gasunie, NaTran, OGE, SNAM and Teréga.

SEPTEMBER

First technical phase of SmHYre completed in Alfortville, a hydrogen and renewable gas flowmetering metrology service, with the adaptation of a hydrogen-specific test and calibration bench.

OCTOBER

New demonstration at the Alfortville site of blue burning and DTR mini gas booster solutions in the presence of Fluxys, Gas Natural Ireland and Gasunie. These innovations have attracted interest from TSOs, Europe's new methane emissions reduction regulations having raised the stakes for green maintenance.



NOVEMBER

It was the 2024 edition of the Key Accounts Club meeting, which brought together about twenty participants from Elengy, GRDF, NaTran, Storengy and Teréga.
This event, which combined presentations with a visit to the Musée des Arts et Métiers, was an occasion for an annual review of R&I advances and opportunities for collaboration in key areas such as methane emissions.

Award-winning start-ups ceremony Open *Innovation Factory* at the Medef, attended by Sandrine Meunier, NaTran's CEO, for a round table "Innovation, a pipeline to progress", alongside Vanina Paoli-Gagin, Senator of Aube, and Christophe Lienard, Innovation Director at Bouygues.

DECEMBER

The 2024 edition of the NaTran Innovation Challenge reached a very satisfactory conclusion! The challenge, which invites our employees to improve our current practices and envision our future, saw 273 participants submit 102 applications in three categories (Performance/ Sustainable Future/ Development), resulting in 20 winners in different areas. In all, six national winners (picked by a national jury) and three Intrapreunariat winners (a first in 2024) were selected. One NaTran employee prize and three CRE prizes were also awarded. The challenge ended with an awards ceremony on the Seine on 12 December.

OUR FIVE RESEARCH PROGRAMS

OPTISE

Optimising the functioning, operation and safety of the gas system

IMPACT

Reducing the environmental impacts of the gas supply chain

NEW CH_4

Preparing the networks for the arrival of renewable methanes

PREPARE

Energy forecasting, network control and optimisation

H_2 & CO_2

Preparing the networks for the arrival of hydrogen and CO_2

Optimising the functioning, operation and safety of the gas system

Optise

Carine Lacroix
Program coordinator
OPTISE

« We are harnessing advances in AI to develop algorithms to predict failures, improve reliability and optimise maintenance. »

In a context of changing practices and the growth of new technologies, our OPTISE program develops and delivers innovative solutions designed to optimise the functioning, operation and safety of gas infrastructure.

To secure the integrity of the network, our experts investigate how corrosion degrades steel and develop innovative solutions to slow down this process. In parallel, the OPTISE program is testing new inspection technologies and developing automated solutions to analyse failures.

OPTISE is also working on improving our operational and economic performance while maintaining high safety levels. As AI continues to improve, our experts are developing algorithms to predict failures, improve equipment reliability and optimise our maintenance policy. In addition, OPTISE is exploring the use of new materials (composites, polyamide) for pipelines, the potential benefits of which are analysed in the laboratory and on site.

Finally, OPTISE prioritises one key objective: prevent industrial accidents and predict their outcomes. Our teams are studying dangerous phenomena and developing modelling tools. Additionally, our experts are identifying and testing new detection and network monitoring technologies to prevent damage to infrastructure and respond swiftly to pipeline leaks.

Ensuring the integrity of the network

Context and operational goals

We examine the most innovative tools to come up with new ways to ensure gas network integrity, considering several key factors, including:

- Corrosion within steel pipelines, which varies with the environment;
- Knowledge of the network's mechanical properties;
- New methods and digital tools to assess pipeline degradation risks;
- Metal pipeline inspection, using non-destructive technologies.

Our main R&I challenges

Corrosion
- Understanding, improving and developing anti-corrosion solutions;
- Improving the reliability of cathodic protection methods and troubleshooting;
- Monitoring corrosion treatment.

Steel integrity
- Improving our knowledge of steel used across our networks;
- Evaluating failure criticality;
- Identifying and testing repair techniques by type of failure;
- Identifying and testing non-destructive inspecting and testing techniques to increase the inspectable part of the network.

Achievements in 2024

Corrosion
- Study completed on ways to reduce corrosion in uncoated stored pipes;
- Testing the resistance of coatings to contamination;
- Evaluating and validating the performance of bio-based fill material compared to conventional coke dust;
- Evaluating corrosion risk for in-service pipelines within unfilled sleeve installations;
- Testing a coating to prevent pressure reduction stations freezing;
- Assessing corrosion risk under continuous stray current conditions.

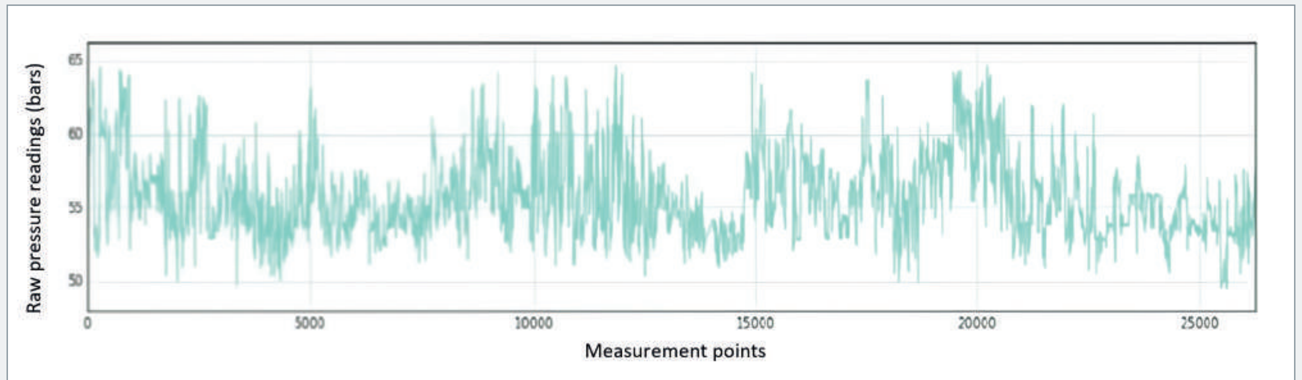
Steel integrity
- Compiling characterisation data for all steel used across our infrastructure;
- Researching non-destructive inspection and testing tools;
- Researching pressure cycling counting methods and cycling severity metrics for evaluating pipeline fatigue performance.

Objectives for 2030

Corrosion
- Research and apply innovative techniques to measure the effectiveness of cathodic protection;
- Research the effects of over-polarisation, depolarisation and soil resistivity on pipeline integrity and implement practices to restrict their impact;
- Identify, research and test corrosion factors affecting pipelines (e.g. electrical interference, immediate pipeline environment, etc.) ;
- Test and roll out methods and technologies to prevent pipeline corrosion (new coatings and paints, alternative earthing methods, etc.).

Steel integrity
- Improve our understanding of the network's mechanical properties;
- Research and test new pistons and unconventional tools to increase the inspectable portion of the network;
- Develop AI algorithms to improve how integrity data is processed and evaluate the criticality of failures within pipelines;
- Research the impact of climate change on pipelines: torrential flooding, falling rocks;
- Implement criticality analysis techniques for potential failures: indicators for monitoring pressure cycling on pipelines, analysis models for different failure types (e.g. crack propagation), methods for treating pipeline dents, updated technical standards in the Failure Analysis Guide;
- Identify and test failure repair techniques (e.g. welding defects);
- Develop a digital tool to optimise maintenance practices.

→ Our flagship project



Actual fatigue cycles in a pipeline.

PARTNERSHIP
JIP formed of Air Liquide, GESIP, NaTran, SPMR, Teréga, Total Energy and Trapil.

Pressure cycle monitoring: what methods exist? What are the severity indicators?

Recent accidents underscore the need for solutions to integrity problems. We were selected in 2024 to carry out a study marking the fourth iteration of a collaborative research program (JIP 4), led by a consortium of pipeline operators and overseen by GESIP (Oil and Chemical Industry Safety Research Group).

Our study identified a small number of pressure cycling counting methods, mostly sourced from various standards and references. The *Rainflow* method, robust and easy to use, is the most widely used. Also intended to identify severity metrics for pressure cycling to assess the fatigue life of pipelines used to transport fluids under pressure, our study highlighted the difficulty in obtaining a standard criterion, the indicators dependent on the parameters of the given installation examined. A model based on a specific metric (*Spectrum Severity Indicator* – SSI), used to determine a cycle's level of dangerousness, may be a viable option to assess and compare the risk levels of several pipelines with defects.

Ensuring optimum cost/performance/safety for network operation and maintenance

Context and operational goals

The equipment installed on NaTran's network must ensure the gas security of supply in complete safety around the clock. Consequently, our OPTISE program is there to:

- Manage the reliability of equipment and predict anomalies;
- Implement innovative industrial asset management practices;
- Deploy new investment strategies to reduce costs.

Our main R&I challenges

Industrial asset management

- Developing models and tools for analysing the reliability and maintenance needs of equipment and installations;
- Improving and developing maintenance solutions and techniques, predictive ones in particular;
- Optimising maintenance policies with regard to cost, performance, safety and environmental impact criteria;
- Ensuring high levels of infrastructure availability and safety;
- Optimising the OPEX/CAPEX* management of industrial assets.

Costs of works and new materials optimisation

- Identifying and testing new materials to increase the lifespan and reduce installation costs of pipelines;
- Optimise planning and construction stages to avoid damaging existing assets.

* OPEX: operating expenditure; CAPEX: capital expenditure

Achievements in 2024

Industrial asset management

- Developing the RelIAmat reliability analysis tool for industrial assets, incorporating AI to optimise data utilisation;
- Streamlining the predictive maintenance of reverse flow compressors: formalising a digital twin methodology and investigating fault data;
- Improving the predictive maintenance of regulators through connected pressure recorders: using pressure data to identify performance drift and threshold breaches;
- Performing predictive maintenance tests on GRDF and NaTran regulators: identifying key physical parameters to detect and troubleshoot major anomalies;
- Modelling and estimating the effect of preventive and preventive maintenance actions on ageing industrial assets;
- Optimising the routes of monitoring rounds.

Costs of works and new materials optimisation

- Prepared an experimental project to rehabilitate a steel pipeline with a composite pipeline, in Gendrey, in the Jura region;
- Tested and developed non-destructive testing (NDT) technologies suitable for composite pipelines.

Objectives for 2030

Industrial asset management

- Identify and develop use cases for the application of artificial intelligence to significantly improve efficiency of industrial asset management;
- Continue development of RelIAmat and help business units onboard the tool;
- Operationally deploy predictive maintenance techniques on pressure reduction/delivery stations and reverse flow compressors;
- Recommend new maintenance policies incorporating the effect of preventive and corrective maintenance actions on the reliability of industrial assets;
- Generally streamline maintenance rounds by integrating network monitoring, periodic station maintenance and unforeseen events;
- Adapt maintenance policies in the medium- and long-term to cope with climate change.

New materials

- Test out composite pipes for repairing steel pipelines at lower costs;
- Identify and test technologies for detecting failures within composite pipes;
- Research the use of polyamide pipelines for transporting natural gas.

→ Innovation

RelIAmat

RelIAmat: new features and tutorials for faster onboarding

Since 2023, our teams have been developing RelIAmat, a tool for using maintenance data from our Computerised Maintenance Management System (CMMS), calculating and tracking equipment reliability indicators based on equipment and failure statistics and supplying data to inform industrial asset management policies.

In 2024, we confirmed, working with the various business units, benefit interest of this tool in meeting the challenges of managing NaTran's industrial assets. Some features have been added, such as maintenance cost analysis and modelling of the effects of ageing on equipment reliability. We also introduced a training module and video tutorials so business units can onboard the tool more rapidly. Next steps planned for 2025: applying the tool in different operational use cases.

NaTran pressure reduction station.

Preventing accidents

Context and operational goals

NaTran's network is facing risks related to third-party work, human intervention and weather conditions, which can have a significant impact on its integrity and therefore on the safety of people and environments. As such, our OPTISE program is investigating high-level technologies and developing new methods to:

- Optimise leak detection and the monitoring of potential threats;
- Improve pipeline detection to determine their precise location;
- Understand the network's behaviour when hazards occur and manage the industrial risk.

Our main R&I challenges

Leak detection and odorisation
- Systematising leak detection by identifying and testing ground or aerial detection solutions;
- Optimising odorisation testing techniques.

Industrial safety
- Managing industrial risk by improving knowledge of hazards and developing simulation tools to assess accident risks;
- Ensuring safe restoration of gas supply to the network.

Pipes monitoring and detection
- Preventing damage to installations by identifying and developing new methods and technologies for ground, aerial or satellite monitoring of the network and detection and georeferencing of pipelines to determine their exact location.

Achievements in 2024

Leak detection and odorisation
- Developing a new aircraft-mounted leak sensor ready for testing in 2025;
- Laboratory-testing a THT (tetrahydrothiophene – sulphur odorant) analyser to assist in the development of this product.

Industrial safety
- Publishing a thesis quantifying the threat of forest megafires on transmission facilities;
- Scenario testing the new version of the FLACS explosion modelling tool.

Monitoring
- Deploying the COSMIC-EYE satellite monitoring solution;
- Testing satellite monitoring of ground instability zones;
- Testing SPADE real-time pipeline monitoring technology via cathodic protection;
- Investigating real-time monitoring technologies: the Pipemon+ solution for monitoring attacks via cathodic protection, and the Threatscan system for detecting attacks using hydrophones installed directly on the pipelines.

Pipeline detection
- Investigating smart pigs equipped with inertia units: assemblying an "innovation package" to improve the accuracy of these technologies.

Objectives for 2030

Leak detection and odorisation
- Identify and test leak detection solutions that can be mounted on aircraft, drones or satellites; aircraft image processing systems to improve reliability of leak detection; and ground leak sensors;
- Implement solutions to automate leak detection without human intervention, especially for hard-to-reach installations;
- Develop new techniques for testing the natural gas odorant (THT).

Industrial safety
- Investigate the permeation of gases in the ground in the event of leaks or overpressure;
- Continue developing a tool for characterising thermal flows during burning operations using a blue flare;
- Model the behaviour of equipment to evaluate its strength and resistance to thermal radiation;
- Develop and test explosion simulation tools.

Monitoring
- Identify and test real-time buried pipe monitoring solutions to alert operators in the event of an accident;
- Test and roll out satellite or aerial monitoring technologies to improve network oversight.

Pipeline detection
- Deliver pipeline geolocation systems to prevent the risk of snagging during work;
- Develop a tool for high-precision (Class A) georeferencing of underground pipelines;
- Develop augmented reality visualisation technology for operating site facilities.

→ Innovations

PARTNERSHIP
NaTran, Teréga

HyLight

Mounting leak detection sensors on airships

In 2024, HyLight was commissioned to test its airship, the HyLighter 35, across 40 km of the NaTran and Teréga network. Objective: test the performance of the airship, carrying a Pergam Falcon 2 leak detection sensor, highly visible due to its size and large enough to carry several sensors. The quality of the leak detection results and the exceptional endurance of the flight give us confidence in experimenting this technology further, especially reducing its dependence on weather conditions.

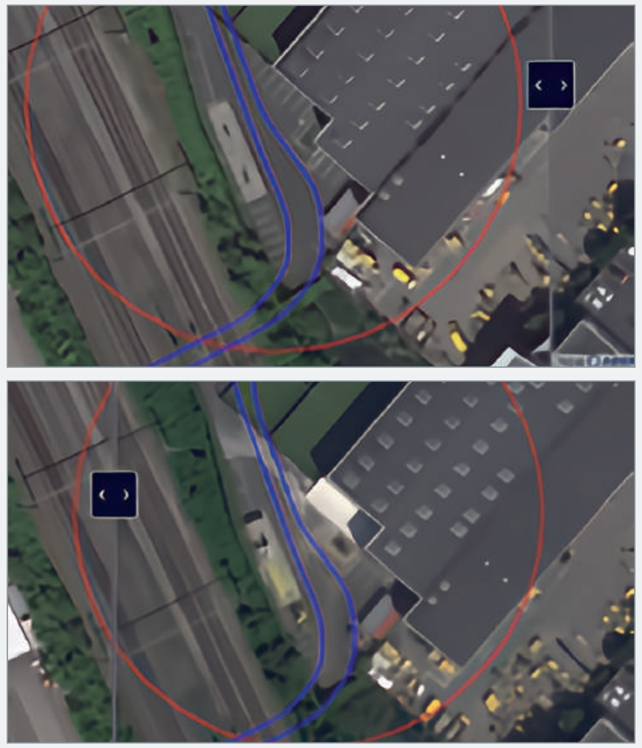
The HyLighter 35 carried a Pergam Falcon 2 leak detection sensor for a distance of 40 km over the NaTran and Teréga network.

Orbital Eye satellite monitoring

orbital eye

To monitor third-party work more easily and efficiently, we launched a project in 2021 to test Orbital Eye's Cosmic-Eye monitoring system, which is based on satellite radar imagery coupled with optical imagery.

Objective: identify potential threats using AI technology and alert operators via a dedicated application. After four years of testing, we can confirm the potential of this technology, which complements roadside monitoring. Our results have enabled NaTran to target use cases that will be implemented during an industrialisation phase planned in Île-de-France in 2025.



Breach identified at a site in Epinay-sur-Seine.

Reducing the environmental impact of the gas supply chain

Impact

Elodie Rousset
IMPACT program coordinator

« Reducing methane emissions, the carbon footprint of infrastructure and the impact on biodiversity and land use. »

One of the priorities for achieving a coherent energy transition is reducing its environmental impacts. After reducing its methane emissions to 7.9 million Nm^3 in 2023, a reduction of 74% compared with 2016, NaTran continued its efforts in 2024, in a rapidly accelerating regulatory context, as illustrated by the forthcoming European regulation on methane emissions. In addition to reducing its carbon footprint, NaTran has also stepped up its efforts to reduce its impact on biodiversity.

The first priority of our IMPACT program addresses methane-specific challenges: measuring and reducing methane emissions. The second IMPACT priority is focused on reducing the carbon footprint (excluding methane emissions) of gas transmission infrastructure but also of the industry as a whole. Work is being carried out in particular on the energy efficiency of industrial processes and waste heat recovery. This program also carries out research into carbon capture, as the ultimate decarbonisation solution for carbon-intensive industries.

Finally, our third priority, set in 2024, will lead research to improve how we measure and reduce the impact on biodiversity and land artificialisation through consensus-based methods in scientific research.

Measuring and reducing methane emissions

Context and operational goals

Methane emissions reduction represents a priority area for NaTran to mitigate the company's impact on climate change. In 2020 NaTran joined the *Oil & Gas Methane Partnership 2.0* (OGMP 2.0), an initiative run by the United Nations Environment Program (UNEP), which provides an international reporting framework for the transparent and voluntary declaration of methane emissions from gas infrastructures. Winner of the *Gold Standard*, demonstrating the quality of its reporting in 2023, NaTran continued its efforts and successfully retained the title in 2024.

The work done by our IMPACT program meets this objective by contributing to the measurement and analysis of uncertainties and helping to deploy the best methods and tools in compliance with European regulations.

Our main R&I challenges

- Optimising leak detection and repair campaigns (LDAR), so as to quickly and effectively detect fugitive leaks and repair leaking equipment more rapidly;
- Measuring, identifying and developing new direct quantification emission measurement techniques at source level in order to ensure the reliability of emissions factors and the estimates published in reports;
- Understanding, testing and evaluating emission quantification techniques at site level and reconciling these results with source level estimates, in line with the requirements of the highest level of the OGMP 2.0 reporting framework;
- Designing, developing, testing and deploying new methane emissions reduction solutions.

Achievements in 2024

- Incubating the start-up Mirega, developer of an innovative methane detection sensor;
- Continued testing of new drone and tracer gas measurement solutions (already tested in 2023) for site level quantification during an inter-operator campaign (with Storengy and Elengy) to achieve level 5 of the OGMP 2.0 methane emissions reporting framework;
- Testing different fixed methane monitoring solutions on controlled releases at a test site;
- Running an *Open Innovation* program to identify a connected sensor for methane detection applicable to valve and vent cases;
- Researching bio-inspired solutions to improve methane leak detection and temporarily stop leaks.

Objectives for 2030

- Evaluate or co-design temporary repair (or temporary closing) solutions to improve fugitive leak detection and repair campaigns;
- Monitor and evaluate source level quantification solutions and industrialisation of a tool for quantifying fugitive leaks by suction;
- Deliver a reliable site level quantification method for sites;
- Evaluate the performance of continuous monitoring technologies at a compressor station;
- Co-develop standard evaluation methods for quantification techniques;
- Develop solutions to prevent venting;
- Improve knowledge of methane emissions for other gas installations.

→ Flagship projects

PARTNERSHIP
Elengy, Explicit, Force Technology, Storengy

Quantifying methane emissions at a site using a drone

As part of its methane emissions reporting, NaTran must reconcile its source-level emissions inventory with site-level measurements. In 2024, we wanted to continue testing tracer gas and drone solutions. In practice, a measurement campaign was carried out on compressor stations as well as an Elengy LNG terminal and Storengy storage sites. This test in real-time conditions provided an opportunity to collect measurement data at site level and compare it to estimates carried out for each source (a comparative "reconciliation" analysis). The results of the campaign will be used to supply reporting data and to help decide whether to approve or not the deployment of this solution in the years ahead.

Measurement of *site-level* methane emissions by drone at the Courthezon compressor station.

Exploring the potential of continuous monitoring

In recent years, lots of suppliers have developed continuous methane monitoring solutions. These technologies could help to detect new sources of methane emissions at installations, as well as complete measurements and address the issue of emission variability over time. With this in mind, we conducted controlled trials at our testing site in Alfortville to test the features of these sensors and assess their potential for detection and quantification at real sites. The tests showed that some solutions were promising. They will continue in 2025 at working sites.

Controlled on-site testing of continuous methane monitoring solutions at our Alfortville site.

Contributing to decarbonisation (excluding methane emissions)

Context and operational goals

To contribute to the objective of carbon neutrality by 2050, we are working to prevent direct methane emissions by NaTran and reduce the carbon footprint of other company stations.

Our R&I IMPACT program specifically focuses on finding ways to capture waste energy from industrial facilities (heat generated by industrial processes that currently goes unused) and develop methods to put it to good use. The program also contributes to the reduction of emissions downstream of the network, i.e. those generated by the industrial uses of natural gas.

Our main R&I challenges

- Developing recovery and recycling solutions for expansion energy from pressure reduction stations;
- Participating in work groups on the subject of decarbonisation in French and international organisations;
- Understanding, evaluating and participating in the development of solutions – applicable to the various industries using natural gas – to improve the energy efficiency of processes and recover waste heat;
- Informing industrial customers about the most suitable solutions for carbon capture, use and storage applicable to industry;
- Supporting the development of new production processes for low-carbon hydrogen using natural gas, such as methane pyrolysis (production of hydrogen and solid carbon from methane).

Achievements in 2024

- Partnering with Sarus, GTT and Engie for the development of micro-liquefaction from the recovery of expansion energy, within the framework of CITEPH's *Open Innovation* program;
- Benchmarking combustion and unburnt fuel analysers for the industrial and mobility sectors;
- Exploring bio-inspired carbon capture solutions;
- Incubating the RevCoo industrial smoke recycling start-up;
- Continuing the CHOC project for the development of a low-carbon boiler for steam production;
- Partnering with Materia Nova, a methane pyrolysis technology developer, to test hydrogen and solid carbon production.

Objectives for 2030

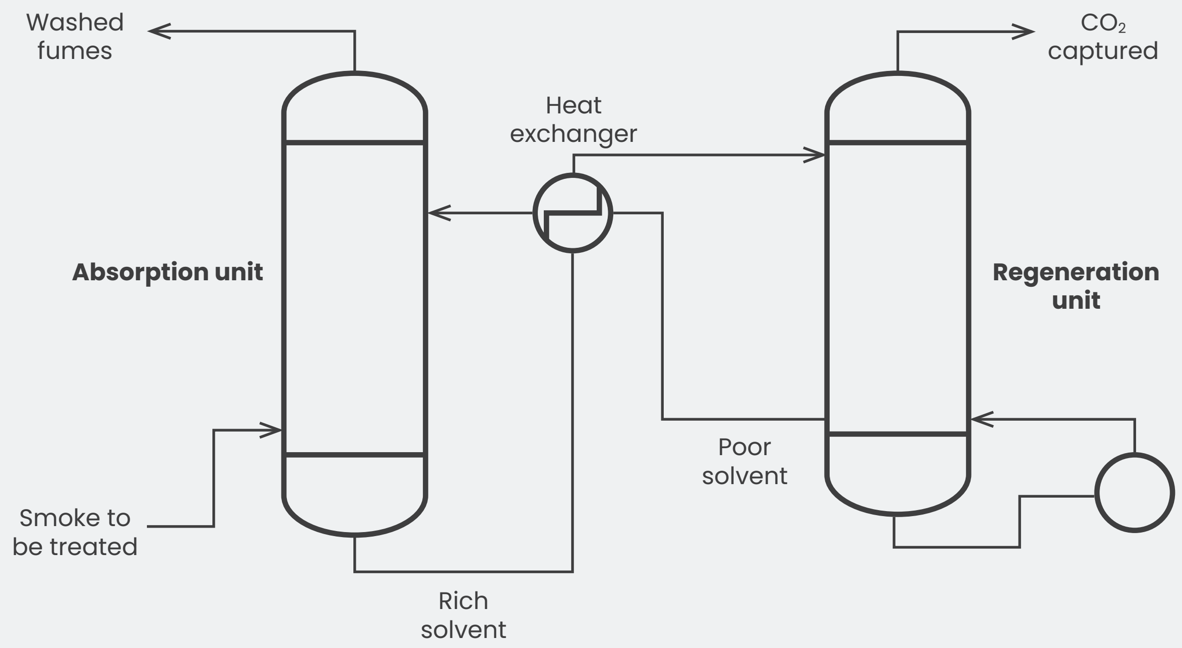
- Deploy solutions for the recovery and recycling of waste expansion energy applicable to different use cases;
- Support industrial customers with the energy transition and their decarbonised investment choices;
- Support technology rollout to shrink the carbon footprint of industrial customers (innovative gas technologies, technologies using renewable gases, waste heat recovery technologies, CCUS* technologies and methane emissions detection);
- Contribute to sector-specific energy efficiency guides;
- Support the deployment of new, more mature processes for producing low-carbon hydrogen using natural gas (methane pyrolysis).

*CCUS, which stands for *Carbon Capture, Use and Storage*: technologies for the capture, storage and use of CO_2 which entails capturing carbon at its source of production and then storing and recycling it.

→ Our flagship project

Carbon capture: a literature review and an inventory of available technologies

We conducted a comprehensive study looking at the new generation of technologies and the latest R&I advances in carbon capture processes. The literature review analysed, to name but a few, various hybrid systems that combine absorption and membrane separation, as well as the new generations of solvents for absorption-based carbon capture. The study also looked at the different ways to optimise carbon capture processes, such as using intermediate cooling in the absorber and dividing the solvent stream, depending on which solvents are used. Finally, an inventory of carbon capture technologies, based on interviews with different technology providers, was also carried out.



The absorption-based carbon capture process

Reducing impacts on life

Context and operational goals

NaTran owns extensive land and industrial infrastructure, which puts pressure on the environment. Consequently, NaTran is implementing a binding environmental policy that aligns with the COP15 Biodiversity Agreement, which aims to halt nature loss by 2030.

Produced in line with the company's CSR commitments, this policy is implemented by each business unit, with the R&I dimension supported by the IMPACT program. It covers all NaTran assets and sites through a global approach that takes into account the specific needs and realities of each business unit. For biodiversity, our work covers three main areas: sites and land footprint, pipeline corridors and cross-cutting issues. Objective: expand and enrich our knowledge on biodiversity, remove any bottlenecks and uncertainties encountered and develop a scientific and technical ecosystem in this field.

Our main R&I challenges

- Identifying robust and recognised methods and tools for measuring and monitoring the status of biodiversity;
- Creating a biodiversity map at NaTran to aid decision-making and report on actions and progress;
- Informing business units on changes to their practices and projects to adopt to reduce their impact on biodiversity;
- Increasing environmental value by improving sites and finding alternative ways of using pipeline corridors;
- Taking action against invasive alien species during asset construction and their lifespan;
- Training NaTran stakeholders concerned by biodiversity and involve them in improvements;
- Building a technical-scientific network focused on biodiversity to create practical tools for implementation, enhancing our understanding and increasing the impact of our actions.

Achievements in 2024

- Drafting the medium-term R&I biodiversity roadmap, co-developed with business units who were asked for their needs and ideas;
- Analysing innovative methods of measuring and monitoring biodiversity through acoustics, pollen and environmental DNA, and groundwork for testing;
- Launching and completing a project to develop joint environmental management plans (JEMPs) on sites over 5 ha;
- Prefiguring a reference mapping tool for NaTran, enabling the qualified observation of company biodiversity hotspots and the monitoring of developments;
- Participating in the ITTECOP (Transport infrastructures, energies, territories, ecosystems and landscapes) research program led by the Ministry of Ecological Transition in coordination with Ademe, as a funder of the 2024 call, and familiarising the scientific community with gas supply infrastructure challenges through the seminar;
- Developing an R&I biodiversity network by building relationships with key partners: industry peers, academics, NGOs, authoritative public institutions, etc.

Objectives for 2030

- Deliver a toolbox of externally recognised solutions and indicators, successfully implemented internally by NaTran, for biodiversity measurement and monitoring;
- Implement and continually update a baseline NaTran mapping tool, providing a qualified view of biodiversity hotspots and action-related developments;
- Expand JEMPs to all medium and large NaTran sites, extending to all sites over 5 ha by 2028;
- Support front-line business units and operators with biodiversity issues, so they can switch from R&I projects to actions fully integrated in their business processes;
- Establish a strong R&I network adapted to NaTran's biodiversity needs.

→ Our flagship project

PARTNERSHIP
Ouvert de Pocheco, UTT

Deployment of a joint environmental management plan for large sites

In 2024, we carried out an environmental assessment on our interconnection station and premises in Alfortville and worked with the operators to define a target vision and the actions to be taken. With the help of our expert partner and motivated and dedicated local team, we drew up a joint environmental management plan (JEMP) and list of priority actions to be implemented in the short and medium term.

This work is co-led by the Innovation team and supported by the bEES group, a team made up of different NaTran departments that helps operators adopt biodiversity practices. Our JEMP was also an opportunity to collaborate with Troyes University of Technology: four teams of students took up the challenge of imagining innovative and eco-responsible solutions for NaTran facilities in Aube.

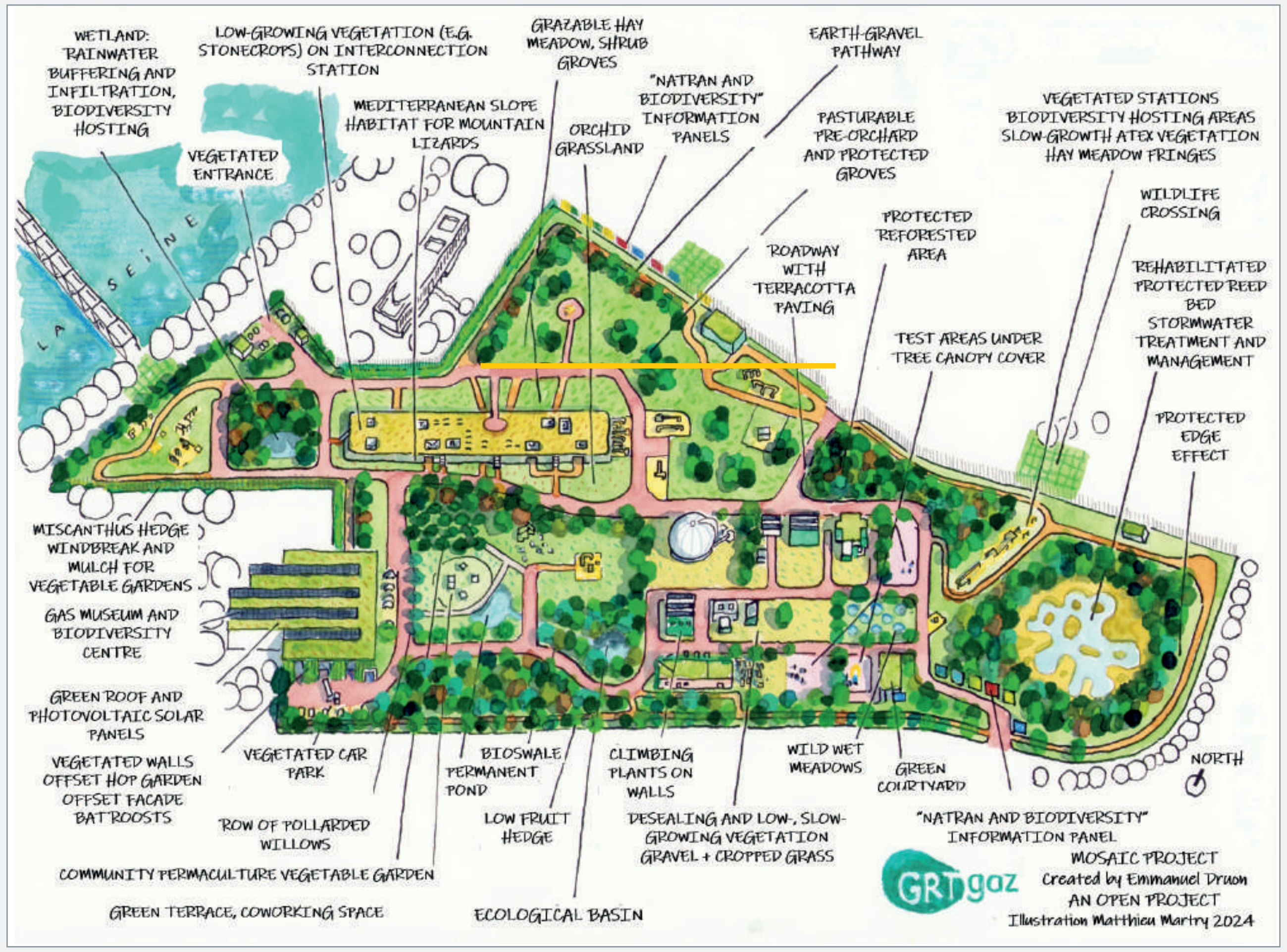


Illustration of recommended improvements at our Alfortville site.

Preparing the networks for the arrival of renewable methanes

NEW CH_4

Dairo Ballestas Castro
Program coordinator
NEW CH_4

« To support the development of renewable and low-carbon methane, we analyse the composition of different gases to assess and manage their potential impact across the entire value chain. »

The development of renewable and low-carbon methane gases (new methanes) is key for moving towards an energy mix that achieves carbon neutrality by 2050, within the framework of a national circular economy strategy. The figures speak for themselves: in 2024, methanisation, the most advanced renewable gas technology in France, saw 731 sites with a total capacity of 13.8 TWh inject biomethane into the networks. The target for 2030 is to produce 44 TWh of biomethane, and in parallel stakeholders in the gas supply chain will make innovative renewable gas production technologies – pyrogasification, hydrothermal gasification and *power-to-methane* – a reality in the near future.

One of our main focuses in our NEW CH_4 program is analysing the composition of new methanes to assess and manage potential impacts on the entire gas value chain, from injection into networks to its final destination through distribution, adjacent TSOs, gas storage and industrial customers.

The development objectives of new methanes underscores the importance of R&I on injection plants for these gases: improving their performance, reducing costs, strengthening the activities of our operations teams and increasing the satisfaction of connected producers.

Consolidating the technological building blocks of the pyrogasification and hydrothermal gasification process chains thanks to our R&I activities is essential for accelerating the emergence of these innovative technologies.

Managing the potential impact of the composition of new methanes

Context and operational goals

Understanding the wide range of new methane compositions produced from methanisation, hydrothermal gasification* and pyrogasification** is crucial in terms of assessing their potential impacts on the environment, on safety and on applications, the foundation of NaTran's corporate responsibility. To accommodate new methanes in the natural gas value chain, we must:

- Develop and implement state-of-the-art analytical methods for new methanes;
- Research innovative solutions for managing the O_2 contained in biomethane;
- Assess potential impacts related to gas compositions.

Our main R&I challenges

- Developing analytical systems for the reliable, in-depth analysis of new methanes;
- Ensuring the long-term industrialisation of reliable analytical systems for spot-checking the new methanes injected;
- Adapting tools to learn about the composition of new methanes, both injectable and unpurified, from innovative technologies;
- Assessing the potential impact of the various compounds found in new methanes, in particular those related to industrial customers who may be sensitive to the O_2 content in biomethane;
- Offering technical solutions for mitigating potential impacts associated with new methane compositions. The key challenge in 2024 has been managing the O_2 content of biomethane, which will require a range of solutions tailored to different scenarios and conditions.

*Hydrothermal gasification: process for recycling liquid or moist organic waste (or even dry, with the addition of only water) based on thermochemical conversion at high pressure (210 to 350 bar) and high temperature (360 to 700°C). Injectable renewable and low-carbon gases are produced, along with recoverable inorganic co-products (minerals, metals, nitrogen and/or water depending on the waste recycled).

**Pyrogasification: a process for recycling solid waste that breaks down the material into different gaseous molecules by heating it to very high temperatures (between 800 and 1,500°C) with little or no oxygen present.

Achievements in 2024

- Building a test bench and testing our solution in the laboratory to reduce the oxygen level in biomethane;
- Starting on-site testing (methanisation facilities) of technical solutions to manage the oxygen content: three experiments conducted and two more in development;
- Securing a more favourable outcome for oxygen levels during the revision of the European standard for H-gas quality (EN 16726), where we actively participated as head of the French delegation;
- Launching the European BIOSTAR 2C project led by GERG (European Gas Research Group): carrying out in-depth analysis campaigns on biomethane from ten injection plants, and starting corrosion testing on steel when exposed to oxidising compounds in biomethane;
- Optimising characterisation methods for new methanes, as part of a thesis with ESPCI Paris (Paris School of Industrial Physics and Chemistry).

Objectives for 2030

- Find concrete solutions for managing oxygen in biomethane in France to meet the requirements of NaTran sensitive interfaces;
- Carrying out gas analysis campaigns in France and across Europe on the first injection projects for innovative renewable gas production technologies to produce new methanes for injection (pyrogasification, hydrothermal gasification and *power-to-methane****);
- Assessing the potential impact of the composition of new methanes on the gas value chain.

****Power-to-methane*: a technology that produces a syngas, e-methane, which can be stored and directly injected into the transmission network, from green hydrogen derived from renewable electricity and CO_2 emitted by industrial sites or extracted from biogas.

Our flagship project

PARTNERSHIP
Partners in on-site testing: Méthamoly, Prodeval

Ferric salts for reducing oxygen levels in biomethane

To reduce the oxygen content of biomethane, our experts have developed an innovative solution based on desulphurisation and deoxygenation using ferric salts. These salts absorb H_2S and are then regenerated by oxygen. We tested the solution in two locations:

- in the laboratory: a test bench was set up in our laboratories and an experiment was carried out to test different operating conditions to characterise and optimise the solution;
- on site: an experiment was carried out at the Méthamoly* (Loire) methanisation facility over several weeks.

The results are very encouraging with a significant reduction of the oxygen levels in the injected biomethane. Next steps include the establishment of more efficient reactors and extensive on-site testing. This solution will join the portfolio of more cost-effective techniques driving the growth of biomethane in France.

*Méthamoly is a regional agricultural project that processes livestock manure from six farms and has injected 125 Nm^3/h of biomethane into the natural gas network since 2019.

Desulphurisation and deoxygenation experiments using ferric salts at the Méthamoly biomethane site.

Optimising the injection of low-carbon and renewable methanes

Context and operational goals

To facilitate renewable gas injection, NaTran is optimising its industrial assets and activities by reducing the costs of injection plants, adapting them to emerging gases, making the service more reliable for producers and consolidating the activities of our teams.

Our R&I centre addresses the challenges of injection plants from design through to operation:

- Identifying and laboratory testing innovative analysis and odorisation technologies;
- Mixture modelling for designing new technical tiers of the stations;
- Acceptance testing of new iterations of stations at the test bench in Alfortville, covering a wide range of real-life operating conditions;
- Using organisational and human factors to update future operations, upskill our teams and promote a culture of continuous learning.

Our main R&I challenges

- Supporting the development of technically reliable and low-cost technologies for the analysis and odorisation of new methanes;
- Adapting our testing facilities and statistical models to assess the performance of analysers and odorisation skids relevant to the technical and economic plan;
- Adjusting our protocols to test new NaTran injection plants according to specific operating conditions on site, in order to reduce potential problems and speed up commissioning;
- Using digital mixture modelling to help with the design of new injection plants;
- Contributing to the optimised use of injection plants and the activities of operational teams to ensure their sustainable industrialisation;
- Reducing methane emissions to meet new European regulations.

Achievements in 2024

- Running an *Open Innovation* program on new low-TRL biogas analysers to support their development;
- Laboratory testing two analysers and an odorisation skid for injection plants in line with our protocols and statistical models;
- Launching the PERL project, winner of the 2024 Innovation Challenge, proposed by experts from the Directorate of Industrial Assets (DAI) to reduce emissions of gases sampled for analysis;
- Launching a troubleshooting approach for the biomethane activities of NaTran's operational teams;
- Developing a tool to determine the minimum length of steel between the injection station and the polythene pipeline;
- Modelling mixtures between biomethane and THT, based on specific geometries, for designing the new tier of injection plants.

Objectives for 2030

- Contribute to the adaptation of NaTran tools for accommodating new methanes using analysis and odorisation instruments that are compatible with the characteristics of new methanes, offer greater performance than existing ones and are more competitive in terms of TOTEX*;
- Improve support at the design stage and test new iterations of injection plants for new methanes sourced from various technologies;
- Add more human and organisational value to optimise the operations of NaTran's operations teams, to cope with the expected increase in the number of injection plants;
- Reduce or eliminate methane emissions from injection plants using innovative technologies and designs.

*TOTEX: total expenditure

→ Flagship projects

An innovation gateway for online low-TRL analysers for new methanes

One of the main challenges of new methanes from innovative renewable gas production technologies is the development of online analysers that can measure their characteristics despite low market visibility.
In 2024, we created an innovation facility targeting under-7 TLR solutions to allow the online measurement of the partial or complete composition of renewable and low-carbon methane.

The most viable technologies will be tested in 2025 by our analytics and chemometrics experts in laboratories using specialised equipment. Our advisory role could help identify areas for improvement, so that the system is fully aligned with NaTran's requirements.

#G6 - Online measurement of the composition of renewable methane

How do you measure and analyse the partial or complete composition of renewable and low-carbon methane?

The *Open Innovation* program tested a successful solution that has been available since February 2025.

PERL: plates to reduce emissions by a factor of 100 and facilitate interventions

The PERL innovation project is developing a design for gas-grade plates at injection plants that aim to reduce atmospheric emissions by a factor of 100, facilitate the interventions of operations teams and maintain the quality of gas analysis.

A *proof of concept* (POC) was launched at a commissioned biomethane injection station to demonstrate the feasibility of the project. This plate can be installed in the new technical tier of injection plants in development as well as in existing plants, through *revamping*.

A POC was launched at the Macé biomethane injection plant (Orne).

Supporting new renewable and low-carbon methane injection technologies

Context and operational goals

NaTran is focusing on the development of innovative renewable and low-carbon gas production technologies, such as pyrogasification and hydrothermal gasification, which recover waste and are fundamental to achieving carbon neutrality by 2050. Nonetheless, commercial projects are lagging behind, while they wait for the passing of French regulations and the necessary financial support.

Our R&I centre helps to remove existing technical barriers, including gas purification. Knowledge of the quality of the gases produced, including those not yet purified, is key to accelerating NaTran's plans to accommodate them. To this end, we are supported by a network of partners including technology providers, waste management companies, academics, local and regional authorities and the main gas supply operators.

Our main R&I challenges

- Successfully combining technologies within pyrogasification pilot projects in partnership with NaTran, despite the inherent risks of research and development.
- Drawing on the strong momentum from high-pressure and low-pressure gas processing technology providers to demonstrate their performance;
- Being in a position to reliably analyse unpurified gases from pyrogasification, methanation and hydrothermal gasification pilot units;
- Having complete, robust data for carrying out life cycle analyses (LCAs) enabling a global, multi-criteria assessment of the environmental impact of pyrogasification and hydrothermal gasification for injection.

Achievements in 2024

- Completing phase 2 of the Plainénergie project aimed at combining, on a semi-industrial scale, pyrogasification and biological methanisation processes in order to validate the quality of gas produced from waste from the Plaine de l'Ain municipal area, including solid recovered fuel (SRF);
- Testing the innovative biological methanisation reactor developed by R&I's Titan 5 pyrogasification project;
- Supporting the implementation of a call for expressions of interest (CEI) on hydrothermal gasification: 24 industrial hydrothermal gasification projects were identified in France to support the circular economy and energy transition;
- Conducting a carbon footprint study on hydrothermal gasification technologies.

Objectives for 2030

- Produce *proof of concepts* (POCs) on high-pressure (hydrothermal gasification) and low-pressure (pyrogasification) synthetic methane treatment solutions;
- Complete testing on existing pyrogasification pilot projects in partnership with NaTran and on third-party pilot projects;
- Participate in testing relevant hydrothermal gasification technologies.

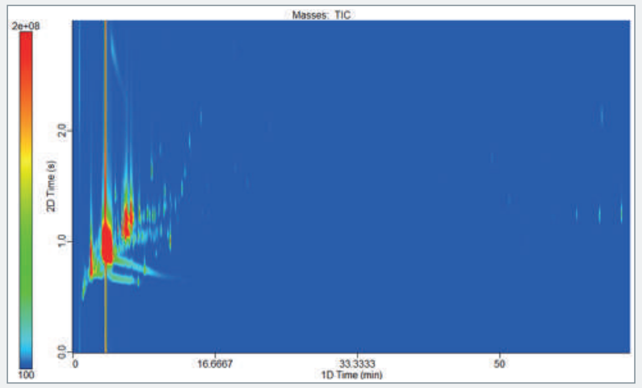
→ Flagship projects

PARTNERSHIP
CCPA (Plaine de l'Ain intercommunal structure), Enosis, SMPIPA (Plaine de l'Ain's joint industrial facilities association) and Séché Environnement

Plainenergy: feasibility tests with solid recovered fuel and grade-B timber

The second phase of the Plainenergy project aims to combine pyrogasification and biological methanisation on a semi-industrial scale to validate the quality of the gas produced from solid waste from the Plaine de l'Ain municipal area (end-of-life timber, bulky refuse, business waste, etc.) that is difficult to recover using conventional methods. Objective: demonstrate the value of this waste treatment solution for local renewable and low-carbon gas production.

In 2024, tests with solid recovered fuel (SRFs) and grade-B timber proved the feasibility of gasifying these feedstocks over several dozen hours of operation on a semi-industrial scale pilot. We carried out six in-depth analysis campaigns of the gases produced using an innovative analysis technique.

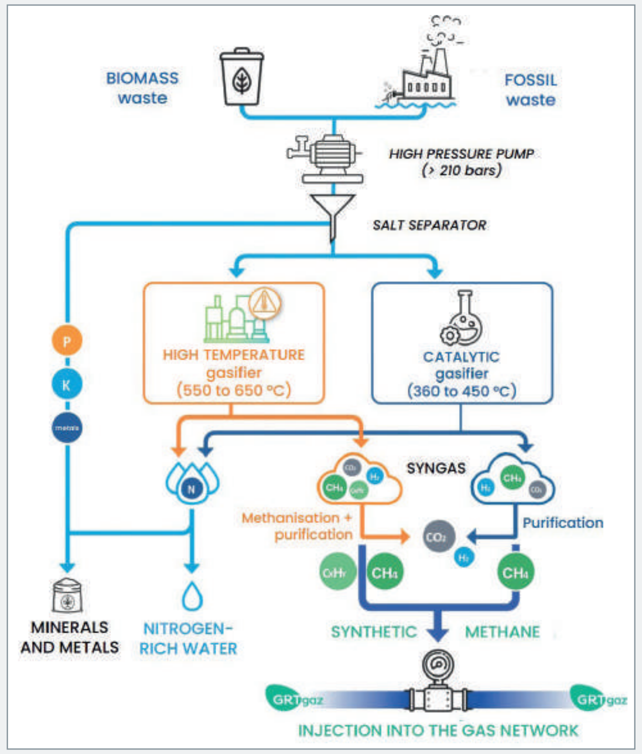


Two-dimensional chromatogram representing the detailed analysis of gases produced from the gasification of grade-B timber and solid recovered fuels (SRF).

PARTNERSHIP
Carbone4, GRDF, SUEZ, Teréga and Total Energies

Hydrothermal gasification: the potential reduction of the carbon footprint confirmed

In 2024, we piloted a study on reducing the carbon footprint of the hydrothermal gasification process, which produces renewable and low-carbon gas by converting a wide variety of waste (biomass, non-hazardous and hazardous waste) that contains or can be easily mixed with water. The results of this study confirm the sustainability of the technology based on European criteria, with a carbon balance in line with the requirements of the European RED III Directive, a representative panel of the two technologies (catalytic and high-temperature hydrothermal gasification) and results comparable with those obtained from incineration with energy recovery.



Hydrothermal gasification process chain included in the carbon balance study.

Prepare

Energy forecasting, network control and optimisation

The environmental transition is both a technological and societal challenge. Our company is reinventing itself, moving from an approach focused on increasing consumption to one centred on optimisation and adaptation.

Gas networks are being redesigned between now and 2035–2050 with the same objective in mind: streamlining their management and their interactions with other energy carriers, adapting their routes to future consumption and production basins and transporting 100% renewable gas, as well as hydrogen and carbon dioxide, through their pipelines.

Our R&I teams are supporting NaTran with its forward-looking activities by developing long-term consumption and production models and predicting multi-energy supply-demand balances for 2035 and 2050. We are also developing network design tools, using a more granular physical description, to optimise investment and operating costs in the future scenarios analysed. We are also updating our network management models, used daily by national dispatching, by adapting them to more dynamic and interconnected operations.

The instrumentation of our installation is also key in achieving a flexible and efficient network. Our testing resources enable us to do just that by identifying and trialling new connected sensors that can meet the management, resilience and efficiency needs of tomorrow's networks.

Christophe Olry
Program coordinator
PREPARE

« We are supporting the transformation of gas networks by forecasting their future geometry, streamlining their management and adapting them to more dynamic and interconnected operations. »

Developing a forward-looking vision of the energy system

Context and operational goals

We are contributing to NaTran's forward-looking activities by developing a multi-energy modelling chain, participating in these studies and harmonising internal practices and tools. In particular, we design and maintain forecasting tools for electricity consumption profiles and renewable electricity production for 2035–2050, along with regionalisation capabilities. Multi-energy supply-demand balance calculations are performed by the market modelling tool ANTARES, and then refined by coupling them with gas network design tools.

We are also developing our partnerships with operators, industry stakeholders and academics. By combining our expertise in gas systems with the multi-energy modelling ecosystem, we are contributing to the emergence of high-level transparent models that can inform French and European energy policies.

Our main R&I challenges

- Modelling renewable gas infrastructure (pipelines, storage, LNG terminals, etc.) and its interactions with other energy vectors (electrolysis, CH_4 and H_2 power plants) in market models and investment models;
- Forecasting the consumption of renewable gas, H_2 and electricity for 2035 and 2050, factoring in global warming and changes in uses, in order to provide NaTran departments with forecast studies;
- Integrating CO_2 in multi-energy models (CCUS*, transmission, sequestration);
- Coupling market models with internal gas network design models to integrate compression costs and validate gas flow compliance with regulatory requirements;
- Enable the scaling down from national-level to regional-level networks, in particular by using regionalisation tools.

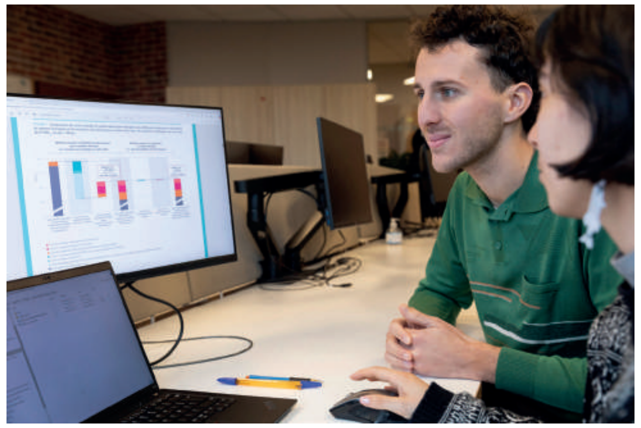
*CCUS (*Carbon Capture, Use and Storage*): technologies for capturing, using and storing CO_2.

Achievements in 2024

- Developing a multi-energy model for 2035: after setting up a modelling chain based on 2050 simulations (used in particular for the joint NaTran-RTE study on hydrogen and electricity infrastructure needs, published in 2023), we are adapting its software blocks and data to align with 2035 forecasts. This adaptation is based in particular on the use of new climatological datasets, developments in production and consumption forecasting tools and updated models in ANTARES;
- Scaling down from national-level to regional-level networks: in collaboration with several business unit managers, we performed data regionalisation activities in 2024. Objective: produce statistics and production and consumption data at regional level from national data, on the basis of distribution keys such as population, housing surface area, tertiary employment and industrialisation;
- Contribution to the PlaneTerr project (cf. flagship project).

Objectives for 2030

- Deploy a global multi-energy modelling chain, integrating operations models, investment models and physical models;
- Improving tool flexibility in terms of downscaling and timeframes;
- Expanding the network and partnerships;
- Modelling the CO_2 chain in forecasting studies;
- Modelling the heat vector.



→ Our flagship project

PARTNERSHIP
Air Liquide, Mines Paris PSL, NaTran, RTE and TotalEnergies OneTech

BUDGET
€11.5 million
Supported by ADEME (€4.5 million)

PlaneTerr: modelling, planning and demonstrating

PlaneTerr – Planning and Energy Coupling at Regional Level – is a project that draws on the expertise of NaTran, RTE, TotalEnergies OneTech, Air Liquide and Mines Paris PSL to achieve three key objectives:

- the development of a multi-energy modelling and planning tool to more clearly identify, among other factors, sources of flexibility;
- regional planning studies, which will explore the synergies offered by cross-sector connections in the regions of Lyon and Fos-sur-Mer;
- the implementation of two on-site demonstrators: an electric vehicle charging platform and a thermal storage system organised by TotalEnergies OneTech.

With a total budget of €11.5 million, including €4.5 million in ADEME funding, the PlaneTerr project is part of the France 2030 program's "Advanced Technologies for Energy Systems" acceleration strategy.

NaTran R&I will bring its specialised expertise on gas network and storage infrastructure (CH_4, H_2, CO_2), particularly by overseeing the modelling of methane and H_2 pipeline stock and the study on energy planning in the Fos-sur-Mer industrial basin.

PlaneTerr, an innovative energy planning and coupling project at regional level.

Optimising infrastructure design and operation

Context and operational goals

Secure gas supply is achieved on a daily basis by national dispatching and four regional monitoring centres, which provide 24/7 oversight of the gas flows and perform remote interventions on the main components of the transmission network.

Within NaTran R&I, we are developing decision support tools that facilitate these missions by optimising the flows and configurations of the interconnection stations on a daily basis. The rapid growth of decentralised renewable gas injection, along with the emerging synergies between energy carriers, demands ever more refined management, and thus higher resolution modelling.

Our teams are also developing infrastructure design models for planning future configurations of the transmission network. In a context of lower consumption, decarbonisation and an emerging hydrogen sector, these tools are proving decisive in terms of predicting the multi-vector energy system of tomorrow.

Our main R&I challenges

- Sizing the infrastructure needs in line with renewable gas developments (pipelines, injection and back-up stations);
- Enhancing the time resolution of decision support tools to enable dynamic management of the network;
- Pairing design and operation models with multi-energy forecasting models, to study the operating costs of tomorrow's networks in greater detail and verify that gas flows meet regulatory requirements.

Achievements in 2024

- Integration of zoning, screening projects based on technical and economic criteria and improving calculation times in the BIOZONE optimisation tool, which determines, the best possible connection to the transmission network for each biomethane production unit;
- Redesigning the compressor modelling function in the MinOPEX model, used by national dispatching to reduce network operating costs;
- Enhancing the performance and functional upgrades of CAPAFLEX, a software application that evaluates a transmission network's capacities and associated usage limitations, and quantifies and optimises available flexibility. In 2024, we carried out work to improve the performance of this tool and consolidate its databases in the light of recent changes made to flows in Europe. These developments have significantly increased its capacity to fix the most complex scenarios and optimise flexibility;
- Ten dynamic transport-distribution reverse flow studies.

Objectives for 2030

- Integrate AI in network operation and design models to reduce calculation times and improve solutions;
- Increase time resolution: move to sub-daily, or even hourly, granularity to adjust the decision support tools we have developed to the increasingly dynamic management of networks;
- Support the buoyant growth of the biomethane sector by carrying out the associated dynamic reverse flow studies, as well as improving the BIOZONE model for sizing network and reverse flow requirements;
- Pairing network physical sizing models with market and multi-energy investment models. Having a global modelling chain will enable NaTran and its partners to explore future scenarios and their impact on energy infrastructure, while reducing adaptation costs for the company.

→ Our flagship project

BIOZONE improves in accuracy

The BIOZONE tool, developed by our teams to optimise the connection of biomethane units and network upgrades, supports the growth of the industry in France. It analyses the technical feasibility, the costs of connecting to gas networks and the costs of upgrading infrastructure to integrate future biomethane production facilities.

In 2024, improvements were made, including the integration of zoning into the technical and economic (I/V) criteria, increasing the accuracy of optimisations. The tool's were also expanded to provide more detailed data, facilitating decision-making for network system operators, which includes when they interact with the CRE*.

*CRE: Commission de régulation de l'énergie – the French energy regulator whose mission is to approve pooled investments proposed by operators to accommodate renewable gases in the networks.

BIOZONE determines in a matter of minutes the best connection possible to the transmission or distribution network for each biomethane production unit.

Managing tomorrow's networks

Context and operational goals

NaTran has set itself the goal of increasing the share of renewable gases injected into the networks fivefold by 2030 compared to 2024 and is actively committed to the development of renewable gases in order to achieve the target of carbon neutrality by 2050. However, promoting biomethane injection requires more dynamic network control, especially at transport, injection and reverse flow facilities.

Equipping these facilities with sensors and connected systems, combined with remote control, is thus one of the key enablers for optimising the proportion of renewable gases injected and consumed on a daily basis. Our teams are also investigating energy-recovery devices that allow sensors to run autonomously, connected gateways for aggregating data from multiple sensors locally, and AI's contributions to these connected gateways to make the information collected greater than the sum of its parts.

Our main R&I challenges

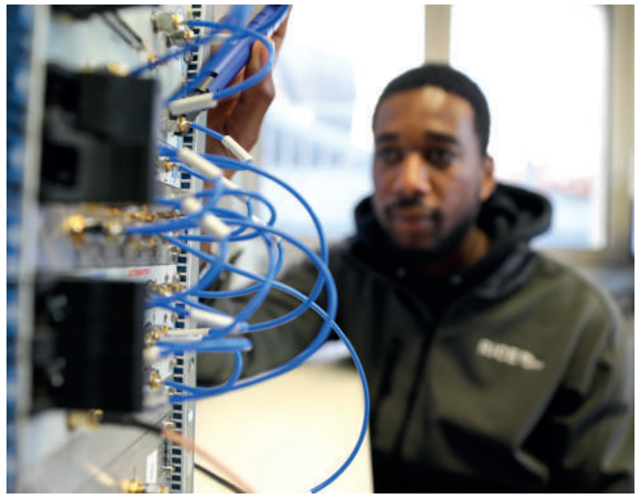
- Identifying and qualifying *Internet of Things* (IoT) solutions adapted to the new use cases identified by the business unit;
- Exploring potential use cases of already deployed IoT solutions, leveraging their full functionality.
- Anticipating future needs, including connected gateways, energy recovery systems and decision support models for network instrumentation in the 2035–2050 timeframe;
- Exploring new technologies, such as AI for industrial instrumentation, 5G and low-TRL IoT solutions.

Achievements in 2024

- Experimenting and quantifying the performance of an innovative energy recovery sensor to identify the potential of this new technology in the gas networks;
- Developing a joint project within the framework of the CITEPH collaborative program for the development of a self-reliant connected ATEX (EXplosive ATmospheres) energy solution;
- Structuring a roadmap related to network instrumentation and identifying areas of alignment with major strategic objectives through to 2030;
- Developing skills associated with vibratory and acoustic signal analysis beneficial to the development of smart networks and predictive maintenance.

Objectives for 2030

- Develop a deployment support model for instrumentation to optimise the deployment of sensors on these networks based on future networks in 2035–2050, use cases and IoT solutions;
- Design an energy-autonomous connected gateway, powered by AI, to aggregate and leverage data collected at a facility or group of facilities.
- Identify and qualify connected sensors suitable for the transmission of low-carbon gases;
- Run a feasibility study on an R&I telecom testing program to prepare for the deployment of innovative connected solutions adapted to new IT architecture.



→ Our flagship project

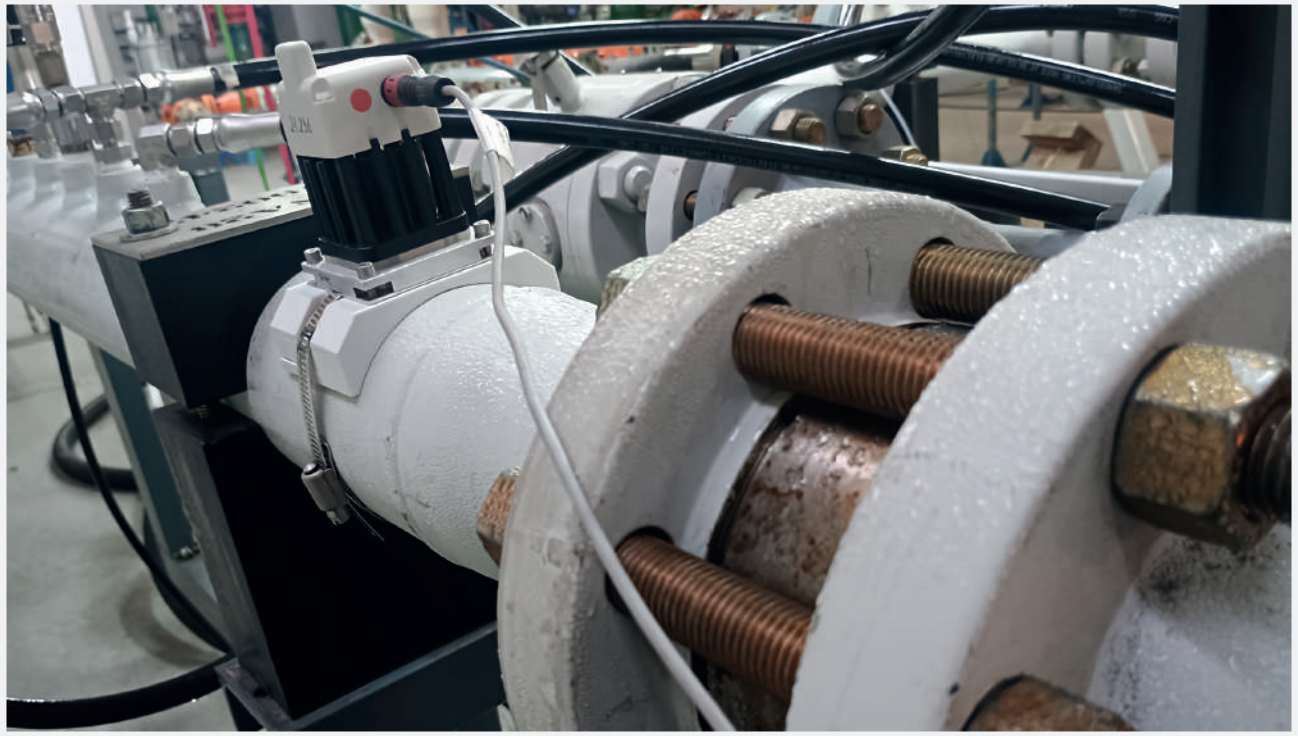
PARTNERSHIP
NaTran, MOIZ and TotalEnergies OneTech R&D

MOIZ Harvestree: sensors powered by waste heat alone

MOIZ develops battery-free sensors, powered by waste heat (or cold) alone, for example from gas network pressure reduction stations. This innovation could potentially lead to significant changes in the industry approach to using IoT sensors, facilitating greater digitalisation of industrial processes and contributing to the decarbonisation of industrial operations.

Our 2024 trials of MOIZ's Harvestree solution proved encouraging for use cases involving sensors that do not require a high power supply.

Based on these initial results, in 2025 NaTran R&I partnered with TotalEnergies OneTech R&D and MOIZ on a CITEPH project to develop the new Sequoïa power plant. This plant will be optimised for sites with use cases requiring a higher power supply (12-24 V) and/or use cases requiring high data transfer rates or volumes (for the LTE-M version).



Robust and waterproof, MOIZ Harvestree sensors are powered by thermal losses from the surface on which they are mounted.

Preparing the networks for the arrival of hydrogen and CO_2

H_2 & CO_2

« Contributing to the development of technologies and standards for the transport of H_2 and CO_2, by proposing solutions adapted to developments in the sector and its regulatory and industrial obligations. »

Romain Jambut
H_2 & CO_2 program coordinator

Committed to the energy transition, NaTran applies its expertise in R&I to actively participate in the development of H_2 and CO_2 networks. 2024 was a particularly pivotal year with enhanced regulatory requirements for CO_2 (standards development at national and European level to guarantee transport at optimal purity levels) and H_2 (98% purity threshold for repurposed networks).

In this context, our H_2 & CO_2 programs pursues two clear objectives: ensure the safety and integrity of industrial assets and maintain a high level of quality for transport operator missions. With regard to the transport of H_2, in 2024 we invested heavily in promoting the potential of composite materials, in particular by collaborating with benchmark stakeholders such as the PRCI in the United States. In addition, our new high-pressure test bench will allow us to increase the reliability of H_2 metering equipment and participate in European-scale projects such as THOTH2 (meter tests) and H2FLOWtrace (reference metrological chain). At the same time, we have put a lot of focus on CO_2 to better understand and manage the potentially dangerous effects of this new vector, which is a major challenge.

These actions underscore our commitment to the development of technologies and standards for transporting these new molecules, as we continue to come up with solutions dovetailing with developments in the sector and its regulatory and industrial obligations.

Ensuring the safety and integrity of industrial assets

Context and operational goals

As it extends its expertise to H_2 and CO_2, NaTran must ensure that any operations are carried out under safe conditions equivalent to those applied to natural gas transmission, in the interests of operators and infrastructure and their environment. We also carry out work in five areas of expertise:

- **Mechanical integrity of pipelines, corrosion and permeation:** analysing and accurately characterising possible interactions between H_2 or CO_2 and the crystalline structure of steel used in pipelines;
- **Network equipment:** validating that network equipment (valves, regulators, dampers, seals, etc.) functions properly in the presence of H_2 and CO_2;
- **Safety:** understanding and modelling potential risks from H_2 or CO_2 and proposing solutions for mitigating these risks;
- **Leak detection:** qualifying the different types of equipment for the detection of potential leaks on network infrastructure;
- **New materials:** exploring alternatives to steel (PE, polymers and new materials).

Our main R&I challenges

- Qualifying the various grades of steel compatible with H_2 and CO_2 injection requiring mechanical testing combined with ageing tests on steel in the atmosphere of the vectors studied;
- Strengthening understanding and the ability to manage the effects of H_2 and CO_2, in gaseous and non-gaseous states, on dangerous phenomena in order to adapt operator and infrastructure safety procedures. Particular attention is given to CO_2, which presents a higher risk of toxicity and anoxia;
- Confirming the compatibility of network equipment with the injection of new gases by testing the ageing and functioning of the valves, meters, regulators, dampers, etc. and running additional tests on metering equipment in dynamic conditions;
- Establishing an appropriate specification for CO_2 in gaseous or dense states, to mitigate the effect of impurities on pipeline corrosion.

Achievements in 2024

- Defining the maximum rate of transport of CO_2 in a gaseous state in pipelines, to preserve the lifespan of infrastructure;
- Setting up a permeation lab to measure the hydrogen permeability of various materials under different pressure and temperature conditions, in order to characterise these materials, evaluate their compatibility for the transport of H_2 and test the effectiveness of coatings designed to limit the permeation of H_2;
- Qualifying valves and relief valves on FenHYx benches, ageing them in a 100% H_2 environment, and then evaluating their proper functioning;
- Selecting mobile and individual H_2 leak detectors, essential for preventing accidents and ensuring the safety of workers, followed by the laboratory qualification of this equipment and on-site testing;
- Qualifying flares for low-flow H_2 burning operations and validating PERSEE+ for estimating thermal flows produced during burning operations.

Objectives for 2030

- Produce a technical document defining the methods for detecting, evaluating and managing anomalies affecting an H_2 or CO_2 pipeline. It will specify the types of failure, the acceptability criteria and any corrective actions, thus ensuring the integrity, safety and durability of the network;
- Identify and select network equipment compatible with H_2 and/or CO_2 ahead of deployment and the commissioning of the first NaTran projects;
- Come up with innovative *proof of concepts* (POC), either through alternative solutions to steel pipelines or through durable coating applications that block the undesirable effects of H_2 or CO_2 molecules. Objective: demonstrate their performance under dynamic operating conditions and validate their ability to transport new gases safely.

→ Our flagship project

BUDGET
€800,000
of which 50% is funded by the PRCI

Comparative study of composite pipelines for H_2 transportation

The *Pipeline Research Council International* (PRCI) is supporting the development of innovative hydrogen transport solutions by funding a comparative study of composite pipelines. Objective: improve our knowledge and understanding of the performance of various promising composite pipelines available on the market, in order to assess their ability to transport hydrogen safely.

The study is being conducted in two phases:

- a first phase of mechanical tests (over 21 months) to assess the resistance of composite pipelines to various mechanical stresses, in actual operating conditions: simulation of third-party aggression (e.g. simulated impact of a digger), cycling and fatigue, tensile testing, bursting tests;
- a second phase of large-scale 100% H_2 permeation tests (over 15 months) to evaluate the permeation properties of composite pipelines when exposed to pure hydrogen, to assess the risks of leakage and optimise material selection.

Stress and bursting tests measuring the resistance of innovative composite materials.

Maintaining the quality of services provided by the transport operator

Context and operational goals

NaTran's primary mission is to ensure the safe supply of gas that meets the expectations of customers and gas infrastructure operators. The injection and transport of H_2 or CO_2 must be carried out without compromising the historic requirements of natural gas transmission.

Our R&I teams are therefore focused on providing the same high level of measurement (metering and gas quality) and network management and maintenance activities.

- Measurement equipment designed to validate and qualify the correct functioning of network equipment in the presence of H_2 or CO_2 while ensuring continuous monitoring and supporting the development of associated technologies;
- Gas quality: essential for H_2 in order to ensure accurate billing, based on the Gross Calorific Value (GCV) and with an additional challenge for CO_2 which, unlike H_2 or natural gas, will be billed not according to an energy-based index but a mass-based index, implying new measurement and testing requirements;
- Network management: adapt existing NaTran tools and therefore define specific monitoring parameters to follow when using H_2 or CO_2 in the network, and specify new needs and data required.

Our main R&I challenges

- Collaborating with the departments to provide them with the different parameters of importance for the supervision of the operation of the future H_2 and CO_2 networks (cycling, temperature, pressure, etc.), as well as addressing issues related to the reconstruction of gas flows, such as the GCV of H_2 or the mass density of CO_2, which will have a direct impact on the SI tools employed to manage the network;
- Establish a common European benchmark on H_2 and CO_2 specifications and the minimum purity levels transport operators must meet to limit potential negative impacts and achieve an optimal technico-economic situation for the entire chain, from producer to consumer.

Achievements in 2024

- Selecting a CO_2 matrix analyser and producing test protocols, with a view to its qualification at the laboratories in Villeneuve-la-Garenne in 2025;
- Developing a computational core to optimise interconnections and operational configurations in a 100% H_2 environment;
- Carrying out a full-scale measurement campaign to quantify the desorption effects of families of compounds of interest, such as THT, BTEX and heavy hydrocarbons, and estimate their potential impact on the quality of H_2 transportation in a repurposed pipeline, by comparing the results with the standards in force;
- Developing of a tool for calculating the optimal technico-economic levels of hydrogen purity, aimed at reducing the overall additional costs of purification technology, factoring in the short, medium and long-term scenarios.

Objectives for 2030

- Develop tools for optimising H_2 and CO_2 operational and interconnection configurations, with the aim of reducing OPEX and CAPEX, by optimising the internal diameters of pipelines in accordance with network requirements (maximum pressure, compression, etc.), managing pipeline storage (minimum and maximum), and minimising pressure losses;
- Accurately measure the quality of the H_2 or CO_2 transported, and identify trace compounds and impurities that may arise from desorption in repurposed networks or injection plants, in particular through the use of real-time analysers on future networks commissioned.

→ Our flagship project

BUDGET
€280K
75% funded by NaTran and 25% through a BPI "Major Innovations Hub" grant.

SmHYre: a national first in high pressure and high flow H_2 metering

At the end of 2024, the first phase of the SmHYre project to develop a metrological service platform for hydrogen and renewable gas flowmetering at our Alfortville site was completed. This precise phase of adapting a test bench and calibrating it specifically for H_2 (pipework optimisation, H_2 flare, etc) focused on industrial metering up to 2000 Nm^3/h.

SmHYre has helped us participate in two large-scale European projects: THOTH2 (Horizon Europe), a pre-normative project for the qualification of the entire energy measurement chain for hydrogen transport; and H2FlowTrace (EMPIR), a project to create a European traceability chain for the calibration of hydrogen meters (transport and storage). Testing for these two European projects will be carried out on the SmHYre bench from January 2025.

The project targets mainly industrial stakeholders, such as metering equipment manufacturers in France and Europe, gas network and infrastructure operators and metrology laboratories.

Hydrogen can now be supplied to the flowmeter test benches.

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