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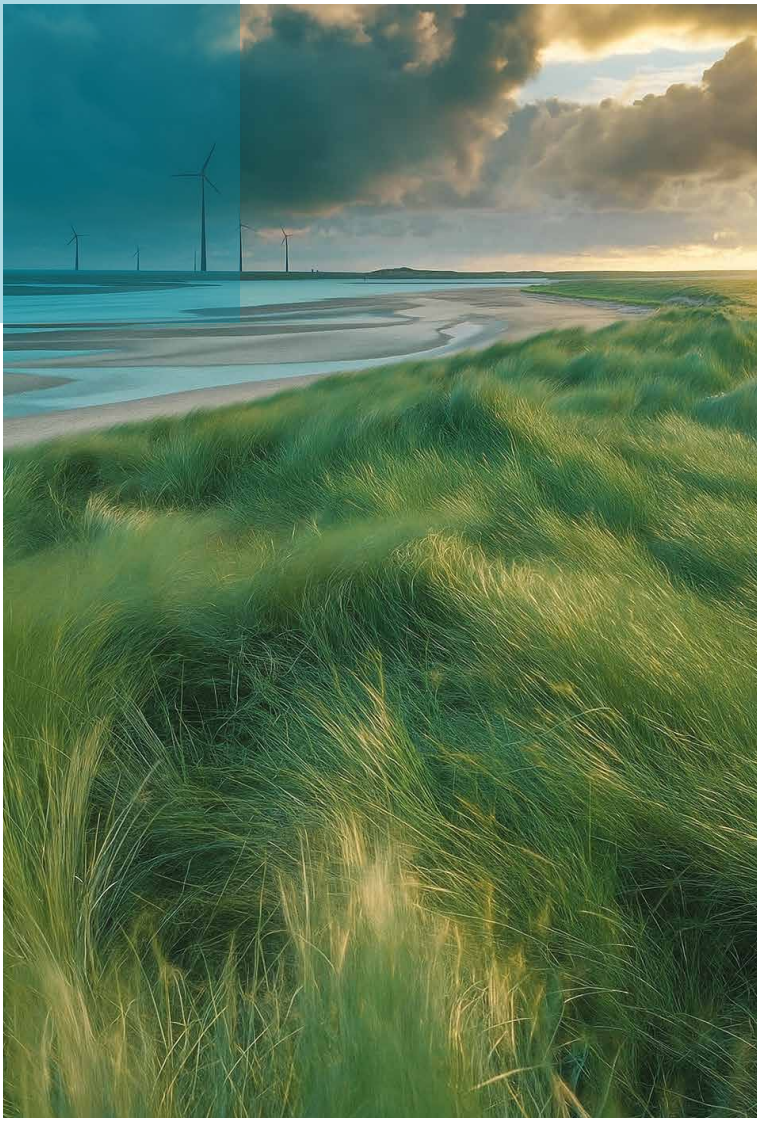
IFP Energies nouvelles

2024

ACTIVITY REPORT

INNOVATING FOR
A LOW-CARBON
AND SUSTAINABLE
WORLD



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EDITORIAL

Pierre-Franck Chevet,
Chairman and CEO

MEETING TOMORROW'S CHALLENGES TODAY

In 2024, IFPEN celebrated its 80th anniversary. This milestone was an opportunity to highlight again the unique nature of our journey: from an institute created to support the energy needs of post-war France to what we have become today, namely an active player in the ecological, energy and digital transition.

True to its general interest mission, this year once again, IFPEN confirmed its position as an innovation catalyst for a sustainable future. Our efforts delivered concrete solutions for a low-carbon, sustainable world. Pre-industrial demonstrators, such as DMX™ and Cheers, confirmed the competitiveness of our CO_2 capture technologies (see p.22). The ongoing industrial roll-out of our solutions by subsidiaries and partners – whether in the fields of self-consumption, bio-based resins or advanced biofuels – illustrates our capacity to convert research into tangible solutions for industry.

Against a backdrop of economic constraints, we have never waivered from our ambitions.

> This year once again, IFPEN confirmed its position as an innovation catalyst for a sustainable future.

The institute maintained the momentum of its innovation drive, with a focus on the efficiency of our investments and the consolidation of our research programs.

2024 also marked a decisive milestone in our role as a benchmark player and trusted third party. Accordingly, IFPEN published a position paper concerning the major regulatory challenges associated with plastics recycling. The French General Directorate for Energy and Climate (DGEC) also tasked us with carrying out a strategic assessment of the natural hydrogen potential in France.

In terms of fundamental research, IFPEN's activities remain firmly anchored in the long term. As well as co-leading three PEPRs (French priority research programs and equipment initiatives), we have actively contributed to four program agencies (AdPs), closely linked to our scientific and technological priorities.

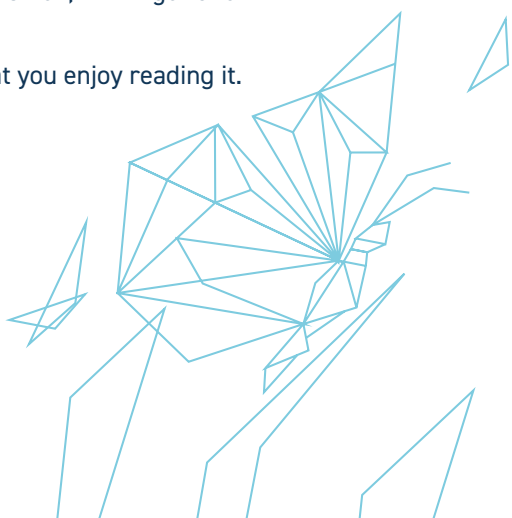
In synergy with our R&I activities, IFP School has adapted its training offer to reflect the challenges of the transition, thereby helping to train the future talents of the energy and environment sectors.

This momentum is also underpinned by the strategic review currently underway on the relocation of our Rueil site to the Saclay campus. The move would be aimed at reinforcing our integration within world-class research and training ecosystems to best meet the challenges of the triple transition.

This annual report, in its new format, reflects the diversity of our actions through the prism of three major challenges: energy, mobility and the environment. It illustrates the strength of our innovation approach, rooted in history but firmly focused on the future.

This report will give you a better understanding of the progress made in 2024 and highlights how IFPEN continues to meet the challenges of the transition, with rigor and passion.

I hope that you enjoy reading it.

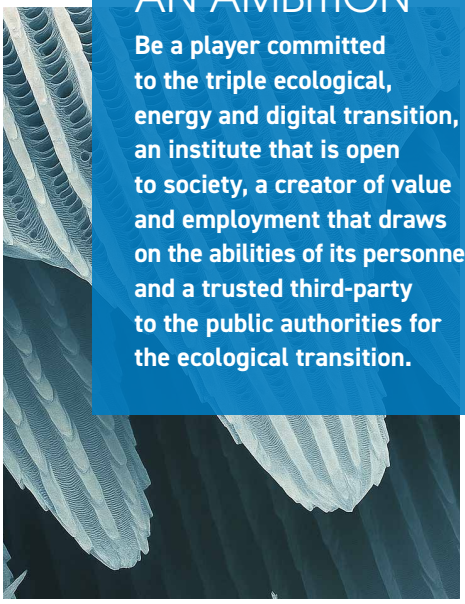


WHO ARE WE?

A COMMITTED PLAYER FOR A LOW-CARBON AND SUSTAINABLE WORLD

IFPEN is the French national institute for research, innovation and training in the fields of energy, mobility and the environment. Its teams develop innovations for a low-carbon, sustainable world, covering the entire chain from scientific concepts through to concrete solutions for industry. From processes to equipment, products, software and services, the institute's low-carbon innovations are paving the way for the energy and ecological transition and facilitating the emergence of the industrial sectors of the future.

To address the climate emergency, IFPEN is positioned as a key player in the ecological, energy and digital transition. Its ambition is to develop and demonstrate innovative, responsible and affordable technologies to meet the challenges of decarbonization, while supporting the reindustrialization and energy sovereignty of France and Europe. As a trusted third party, IFPEN provides its scientific and technical expertise to national and European public authorities to help develop their strategies.



AN AMBITION

Be a player committed to the triple ecological, energy and digital transition, an institute that is open to society, a creator of value and employment that draws on the abilities of its personnel, and a trusted third-party to the public authorities for the ecological transition.

RESEARCH AND INNOVATION TO SUPPORT INDUSTRY

Covering the entire value chain, from fundamental research to industrial transfer, IFPEN's resources accommodate different scale changes, combining:

- **cutting-edge experimental tools,** from laboratories to pre-industrial pilots;
- **numerical simulation expertise** and **high-performance data analysis**;
- **life-cycle analyses**;
- **a strategy of partnerships** with industry, start-ups and academic institutions.

TECHNOLOGICAL SOLUTIONS SERVING THE ENERGY AND ECOLOGICAL TRANSITION

IFPEN focuses on strategic themes.

LOW-CARBON ENERGY PRODUCTION:

wind power, natural hydrogen and hydrogen storage, geothermal energy, large-scale energy storage.

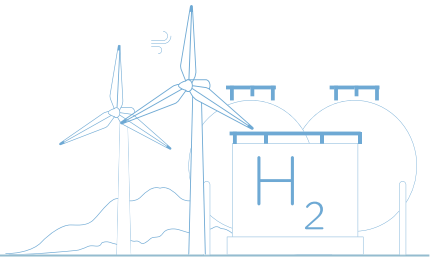
SUSTAINABLE MOBILITY:

electric propulsion (electric machines, power electronics and batteries) and hydrogen (IC engine and fuel cell), sustainable fuels (biofuels and e-fuels).

DECARBONIZATION OF INDUSTRY & THE CIRCULAR ECONOMY:

CO_2 capture, storage and use, advanced plastics recycling and metal recycling, bio-products, water/air/soil management.

IFPEN develops these innovative solutions incorporating environmental and life cycle analyses, as well as a systems approach to guarantee their technical, environmental, economic and societal viability.



As a driver of innovation and the energy and ecological transition, IFPEN boldly imagines and meticulously designs solutions for tomorrow's world.

FROM FUNDAMENTAL RESEARCH TO VALUE CREATION

IFPEN's expertise and ability to innovate are rooted in a fundamental research program which benefits from intense collaboration with other institutions. Its teams are preparing for the future by providing the knowledge base, skills, methods and tools needed to develop innovative new technologies.

IFPEN actively contributes to the creation of wealth and jobs by stimulating the economic development of sectors related to mobility, energy, and eco-industry. Its business model is based on leveraging the innovations developed through research, and marketing them via the Group's subsidiaries and through close partnerships with industry.

In emerging or mature markets, IFPEN creates companies or acquires shareholdings in high-potential companies.

It also supports the development of start-ups and SMEs through collaboration agreements offering them privileged access to its technical and legal expertise.

TRAINING TOMORROW'S TALENTED YOUNG PEOPLE

Lastly, IFP School, IFPEN's graduate engineering school, plays an essential role in preparing future generations and training the future professionals who will drive the energy transition.

Every year, more than 500 students from all over the world are trained there to take up careers in energy, mobility and the environment, with an approach focused on innovation and adaptability to the major challenges of the transition.

Michèle Pappalardo,
chair of the Stakeholders' Committee

Michel Colombier,
member of the Stakeholders' Committee

ESTABLISHING DIALOGUE BETWEEN RESEARCH AND CIVIL SOCIETY

IFPEN's Stakeholders' Committee was set up in 2023 to support the institute's policy of opening up to society. Michèle Pappalardo, committee chair, and Michel Colombier, committee member, share their thoughts on the importance of dialogue in guiding research and addressing societal challenges.

Why is it important for an institute to establish dialogue with civil society?

Michèle Pappalardo. Today, it's essential for a research organization to take into consideration the views of the public. The existence of the Stakeholders' Committee reflects IFPEN's determination to fully take into account the issues facing today's society and to make sure that its research themes are relevant to them. Its choices enable it to remain in step with society's expectations and to avoid overlooking important topics, thanks to the contribution of external perspectives.

What is the role of the Stakeholders' Committee?

Michel Colombier. It has two key roles: firstly, to help IFPEN make sure that its messages about its transformation and the challenges ahead are clear, because it's vital for a modern research institute to be able to explain its work and its purpose if it is to be understood and supported by its stakeholders.

Secondly, and crucially, it enables research projects to be guided according to their social utility and economic performance, while assessing the risks and value of the avenues explored, such as CCUS or plastics recycling. This requires an understanding of the many debates running through society.

How does IFPEN bring solutions to the current challenges facing society?

MC. Building on its historical expertise, IFPEN today tackles energy transition issues by integrating technological solutions, which we believe is a good response to both societal and economic challenges.

MP. IFPEN's research themes seem to us to be well aligned with the priorities of today's world. The future priorities, as set out in IFPEN's Horizon 2035 strategy, also fit squarely with societal concerns. The relevance of IFPEN's strategic priorities is widely recognized by committee members, who freely give their opinion on the directions presented and express any concerns they may have.

WHAT YOU SHOULD KNOW

The Stakeholders' Committee, which has ten members, is chaired by Michèle Pappalardo, appointed by IFPEN's Board of Directors for a renewable period of 4 years.

• **Michèle Pappalardo** was previously chair of the French Environment and Energy Management Agency (Ademe) from 2003 to 2008, General Commissioner for Sustainable Development (2008-2011), Chief of Staff for Michel Barnier (1993-1995) and Nicolas Hulot (2017-2018), chamber president at the French Court of Auditors (Cour des Comptes) and general rapporteur of the Court of Auditors. Since 2012, she has been a member of the French Academy of Technologies.

• **Michel Colombier** is Scientific Director of the IDDRI, an independent policy research institute and platform for multi-stakeholder dialogue, and a member of the French High Council on Climate.

The other committee members are:

Matthieu Auzanneau, Director, The Shift Project

Pauline Bucciarelli, doctoral researcher based in IFPEN's Economics and Technology Intelligence Division

Loïc Chauveau, journalist, Sciences & Avenir

Marie Chéron, e-mobility, transport and environment expert, T&E

Liliana Doganova, researcher at the Sociology and Innovation Center, École des Mines Engineering School, Paris

Camille Megy, doctoral researcher, Natural Gas Economics Chair, IFP School

Alexandre Roesch, general representative, French Renewable Energies Union

Yann Wehrling, 8th Vice-President responsible for the Ecological Transition, Climate and Biodiversity, Île-de-France Regional Council

HIGHLIGHTS

JANUARY

IFPEN GOES TO BRUSSELS

On 1 January 2024, **IFPEN became a permanent member of the Maison Irène et Frédéric Joliot-Curie based in Brussels**. The body brings together 29 French higher education and research players.

SOILCET: INTERNATIONAL MOMENTUM FOR SOIL CARBON RESEARCH

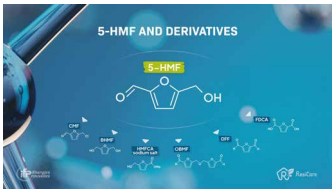
IFPEN's Ressources Énergétiques Carnot Institute and INRAE joined forces to examine the crucial issue of soil as a carbon sink. Together, they galvanized the scientific community by organizing the SoilCET international symposium, a major event designed to tackle the global challenges linked to carbon storage in soils.

FEBRUARY

IFPEN NAMED ONE OF FRANCE'S TOP 500 EMPLOYERS

Capital magazine published the 2024 list of France's top 500 employers. **IFPEN is one of the 500 best-rated companies** (2,000 companies represented).

ANOTHER STEP TOWARDS BIO-BASED, NON-TOXIC CHEMISTRY ON AN INDUSTRIAL SCALE



Celebration of the finalization of the joint development with Michelin ResiCare of the production process for 5-HMF, a bio-based substance used to formulate resins for bonding wood and other materials. This is the final stage before the construction – by 2026 – of the future industrial unit in the Auvergne-Rhône-Alpes region of southern France.

MARCH

FRENCH 2024 AGRICULTURAL SHOW: A SUCCESSFUL FIRST APPEARANCE

For its first appearance at the French Agricultural Show, IFPEN presented its Futurol®, BioTfueL®, Rock-Eval® and Flair™ suite technologies. Its stand welcomed the public, industry representatives, researchers and institutional players.

GENDER EQUALITY INDEX 100/100!

For the sixth year running, IFPEN achieved a score of 100/100. Maintaining this score is testimony to IFPEN's ongoing efforts in favor of gender equality, but also to its capacity to structure itself in such a way as to make this dimension an integral component of its organization.

IFPEN A KEY PLAYER IN STRUCTURING FRENCH RESEARCH IN THE FIELD OF BIO-BASED CHEMISTRY AND FUELS

IFPEN organized workshops at the Rueil-Malmaison site for **the B-Best PEPR calls for projects**, bringing together the French research community in the fields of biomass, industrial biotechnologies and sustainable fuels.

APRIL

LAUNCH OF THE THIRD INTERNAL INNOVATION CHALLENGE

For the third year, IFPEN launched an internal innovation challenge aimed at turning innovative ideas into concrete projects within its incubator. In December, five winners proposing solutions to some major societal challenges were selected.

MAY

OPTIMA: AXENS/IFPEN LAUNCH PCAM PRODUCTION

The OPTIMA (*Outil de ProducTion Innovant de Matières Actives or Innovative active material production tool*) project has just been selected within the framework of Bpifrance's call for expressions of interest aimed at **locating battery production sites in France.**

IFPEN CO-FOUNDER OF THE GEEAUDE™ CHAIR FOR PRESERVING A STRATEGIC RESOURCE

On 31 May, the GeEAUde™ "Groundwater Resources and Interactions with Associated Ecosystems" chair was inaugurated, launched by Avignon University in partnership with INRAE and IFPEN.

JUNE

SUCCESSFUL COMPLETION OF THE CHEERS PROJECT: VALIDATION OF CLC TECHNOLOGY ACHIEVED

Launched in 2017 with funding from the European Union (H2020) and China, the CHEERS project has now been successfully completed. In partnership with Dongfang Boiler Co. and Tsinghua University, a demonstration unit of the CLC process was built, and successfully operated in 2024 with several solid fuel feedstocks. IFPEN, together with TotalEnergies, played a central role throughout the project, from technology development to operational validation. The results were delivered to Europe in June 2024, opening the way for future large-scale deployment.

CONTINUED...

IFPEN CELEBRATES ITS 80TH ANNIVERSARY

Created at the end of the Second World War to develop petroleum technologies and ensure France's technological independence, IFPEN now helps drive the energy and ecological transition by developing a more sustainable, low-carbon energy mix. As heirs to a glorious history, its teams are constantly looking to the future.

JULY-AUGUST

IFPEN AT THE EUROPEAN BIOMASS CONFERENCE

At EUBCE (European Biomass Conference and Exhibition) 2024 in Marseille, teams from IFPEN and the IFPEN Ressources Énergétiques Carnot Institute presented scientific advances and technological solutions for converting biomass into fuels and chemical intermediates, as well as for soil quality analyses.

THE CNRS AND IFPEN INVENT THE ENERGIES OF THE FUTURE

On 11 July 2024, Antoine Petit, Chairman and CEO of the CNRS (French National Center for Scientific Research), and Pierre-Franck Chevet, Chairman and CEO of IFPEN, formally renewed the framework agreement between the two research organizations for a further five

years. The main focus of the agreement is on the energies of the future.

PHD STUDENTS ON VIDEO

IFPEN invited its second-year PhD students to share their stories: committed and enthusiastic, in a video they **talk about their thesis journeys** and tell us what inspired them to take up the scientific challenges of energy, mobility and the environment.

ICC 2024: FRENCH AND LYON-BASED CATALYSIS IN THE LIMELIGHT

The 18th International Congress on Catalysis (ICC) was held in the city of Lyon from 14 to 19 July 2024, buoyed by the vitality of the French catalysis community. Co-organized by IFPEN, the French Chemistry Society, the Fondation de la Maison de la Chimie and IRCELYON, this global scientific event brought together some **2,300 participants**.

SEPTEMBER

IFPEN'S PROPOSALS TO FACILITATE THE DEVELOPMENT OF PLASTICS RECYCLING IN EUROPE

What regulatory framework should be put in place so that advanced plastics recycling can play its full role in Europe? That was the question addressed by the position paper drawn up by IFPEN, which makes **six recommendations** aimed at facilitating its deployment as a complement to mechanical recycling.

LAUNCH OF THE RECORD PROJECT: TOWARDS OPTIMIZED BATTERY RECYCLING

Led by IFPEN and Eurecat with the support of ADEME, the RECORD project targets the development of a recycling solution that maximizes the recovery of materials while **reducing the environmental footprint of the process**.

OCTOBER

2024 SCIENCE FESTIVAL: DIVING INTO AN "OCEAN OF KNOWLEDGE"

During France's 33rd Science Festival, IFPEN researchers **raised public awareness** of the fragile nature of aquifers, the circulation of microplastics in water and solutions to limit our environmental impact.

THE REWIND®PET PROCESS IS LAUNCHED TO MARKET

As promised at the inauguration of a semi-industrial demonstration unit in Japan in October 2023, project partners Axens, IFPEN and Jeplan announced **the market launch** of the Rewind®PET process to adress PET not processable in mechanical recycling.

NOVEMBER

RENEWAL OF THE FRAMEWORK AGREEMENT BETWEEN IFPEN AND INRAE

Pierre-Franck Chevet, Chairman and CEO of IFPEN, and Philippe Mauguin, Chairman and CEO of INRAE, announced the renewal of the framework agreement for a further five-year period.
This commitment marks another milestone in our cooperation to meet the **major challenges of the ecological and energy transition**.

TOWARDS APPROVAL OF THE DMX™ CO_2 CAPTURE PROCESS

IFPEN completed the test campaign for capturing the CO_2 contained in blast-furnace fumes on the pre-industrial demonstrator installed at the ArcelorMittal site in Dunkirk. These results, obtained within the framework of the European 3D project, will pave the way for the finalization of **the approval phase for the DMX™ process**, a prerequisite for market launch.

DECEMBER

IFPEN UNPICKS THE ENERGY TRANSITION WITH L'ESPRIT SORCIER TV

For the last few years, IFPEN has been working with L'Esprit Sorcier TV to raise public awareness of the major challenges associated with the energy transition. In 2024, IFPEN took part in programs exploring key themes: **critical metals and tackling plastic pollution.**

FLORENCE DELPRAT-JANNAUD ELECTED TO THE FRENCH ACADEMY OF TECHNOLOGIES

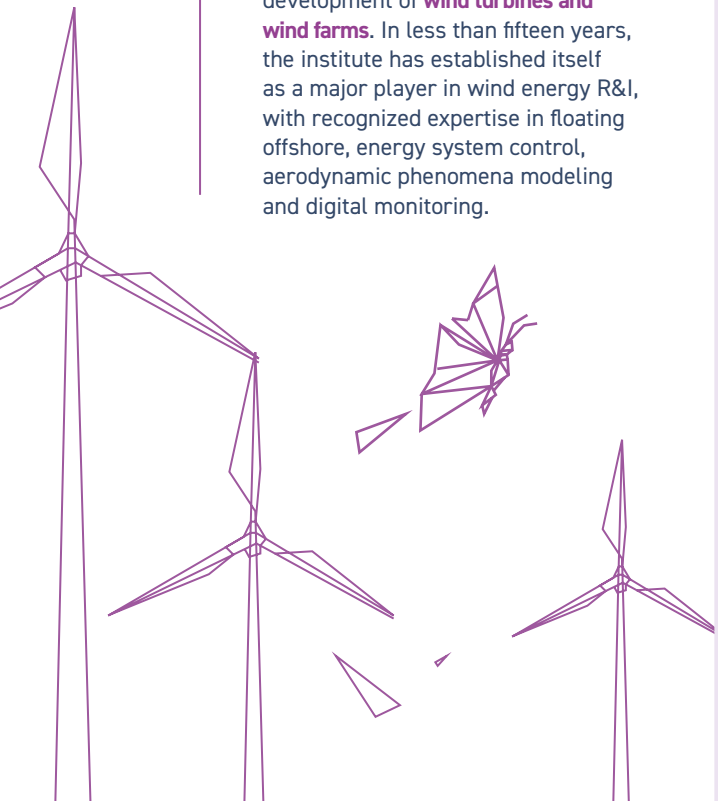
Florence Delprat-Jannaud, now IFPEN's Scientific Director, was elected to the French Academy of Technologies.
This appointment is in recognition of her outstanding contribution to the **decarbonization of industry and energy.**

PRODUCING LOW-CARBON ENERGY

IFPEN proposes processes for producing energy from new renewable resources and offers solutions for the industrial roll-out of offshore wind power, ocean energies and geothermal energy.

IFPEN, A KEY WIND AND OCEAN ENERGY PLAYER

IFPEN designs tools targeting the development of **wind turbines and wind farms**. In less than fifteen years, the institute has established itself as a major player in wind energy R&I, with recognized expertise in floating offshore, energy system control, aerodynamic phenomena modeling and digital monitoring.



GREENWITS®

"GreenWITS®, an IFPEN subsidiary created in 2023, provides industrial players with innovative services stemming from research conducted at IFPEN, particularly in the development of multi-physical simulation codes. These services include farm design, the dimensioning of offshore turbine foundations, turbine monitoring and farm control. In 2024, the CAP (advanced control of wind farms) project, led by GreenWITS® in partnership with IFPEN and Epsiline, won the DEMO-TASE call for projects, securing ADEME funding as part of the France 2030 State-Region Plan initiative. IFPEN is proud to support two young French companies in this new field, including its subsidiary GreenWITS®."

Stéphane Bertholin,
IFPEN Program Manager

TARGET

42.5%

The European renewable energy strategy aims to achieve a 42.5% share of renewable energy in the EU's energy mix by 2030, with ambitions to increase this figure to 45%. This target was set by the revised Renewable Energy Directive, which came into force in November 2023.

NATURAL HYDROGEN: A RESOURCE EXPLORED BY IFPEN

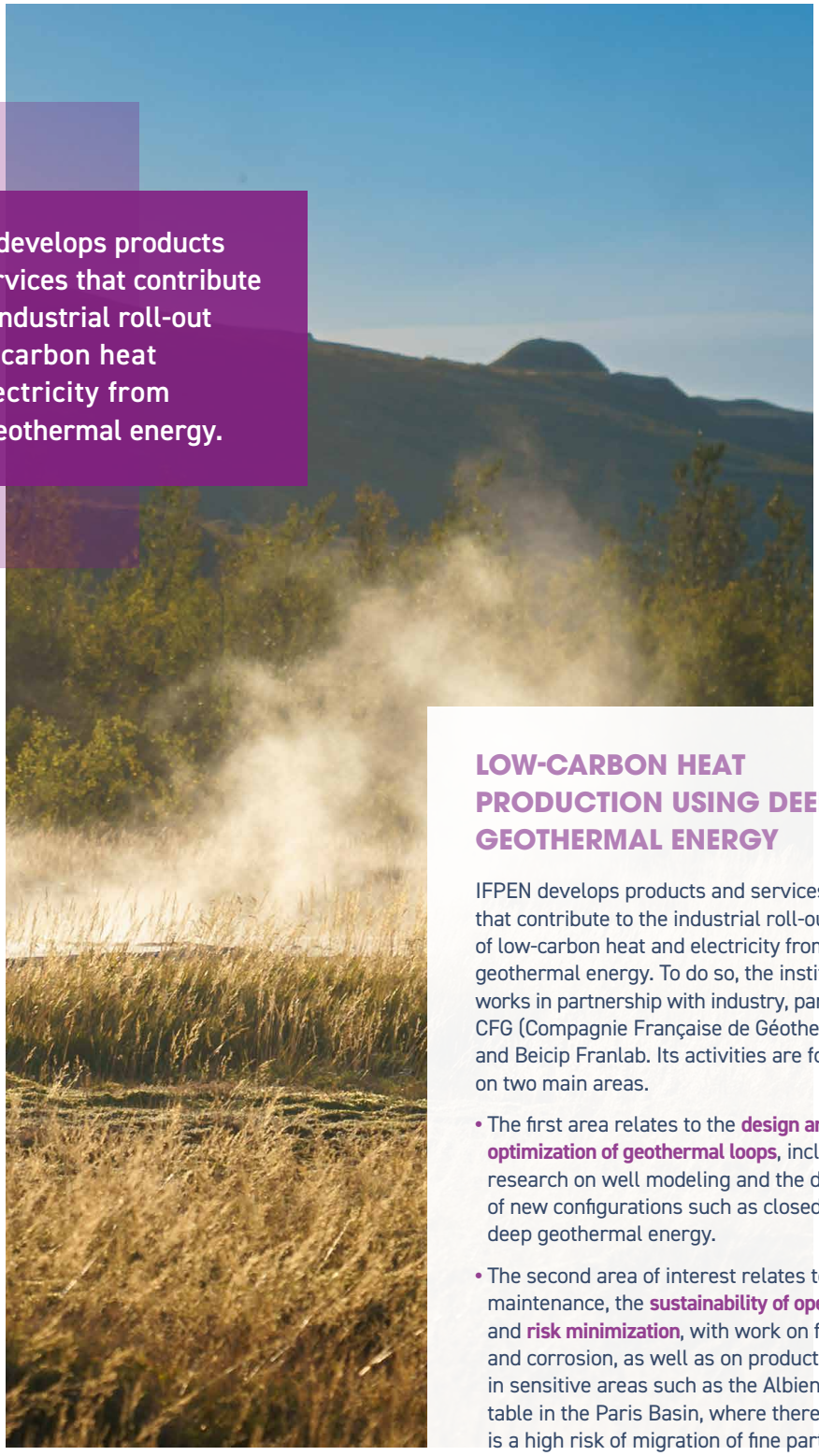
The IFPEN Ressources Énergétiques Carnot Institute took an early interest in **the challenges of the underground environment**, strategic for resources exploitation (heat, hydrogen, hydrothermal fluids/metals, etc.) and for the large-scale storage of fluids. Recent events have given pride of place to **natural hydrogen**, a resource that has been of interest to IFPEN researchers **for over 15 years**.

The IFPEN researcher teams are studying the emanations from various locations on the earth's surface, quantifying the resources available and working to gain a clearer understanding of the processes involved in transforming water into hydrogen deep underground. The research carried out is aimed at supporting the industrial emergence of natural hydrogen production, as well as encouraging the development of the hydrogen **"logistics"** sector, i.e. the transport and mass storage infrastructure.

Yannick Peysson,
IFPEN Program Manager

"There is a growing interest in natural hydrogen. It's a field that lies at the crossroads between scientific research and industrial development. IFPEN has been exploring the existence of this resource on every continent since 2008, under the impetus of researchers such as Éric Deville and Alain Prinzhofer. This pioneering research has established solid expertise and confirmed the existence of natural hydrogen in the underground environment. In 2024, the DGEC tasked IFPEN with coordinating a summary report on natural hydrogen, including an assessment of the potential in France. Moreover, the first industrial studies have now begun, aimed at assessing the potential of various geographical areas."

IFPEN develops products and services that contribute to the industrial roll-out of low-carbon heat and electricity from deep geothermal energy.



LOW-CARBON HEAT PRODUCTION USING DEEP GEOTHERMAL ENERGY

IFPEN develops products and services that contribute to the industrial roll-out of low-carbon heat and electricity from deep geothermal energy. To do so, the institute works in partnership with industry, particularly CFG (Compagnie Française de Géothermie) and Beicip Franlab. Its activities are focused on two main areas.

- The first area relates to the **design and optimization of geothermal loops**, including research on well modeling and the design of new configurations such as closed-loop deep geothermal energy.
- The second area of interest relates to maintenance, the **sustainability of operations** and **risk minimization**, with work on filtration and corrosion, as well as on productivity in sensitive areas such as the Albien water table in the Paris Basin, where there is a high risk of migration of fine particles.

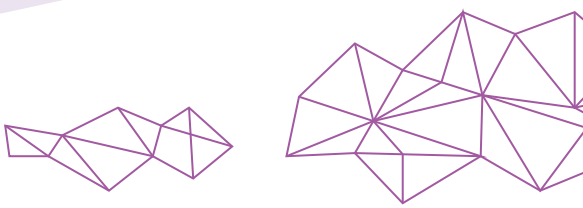
DIGITAL SOLUTIONS FOR SUBSURFACE MODELING AND SIMULATION

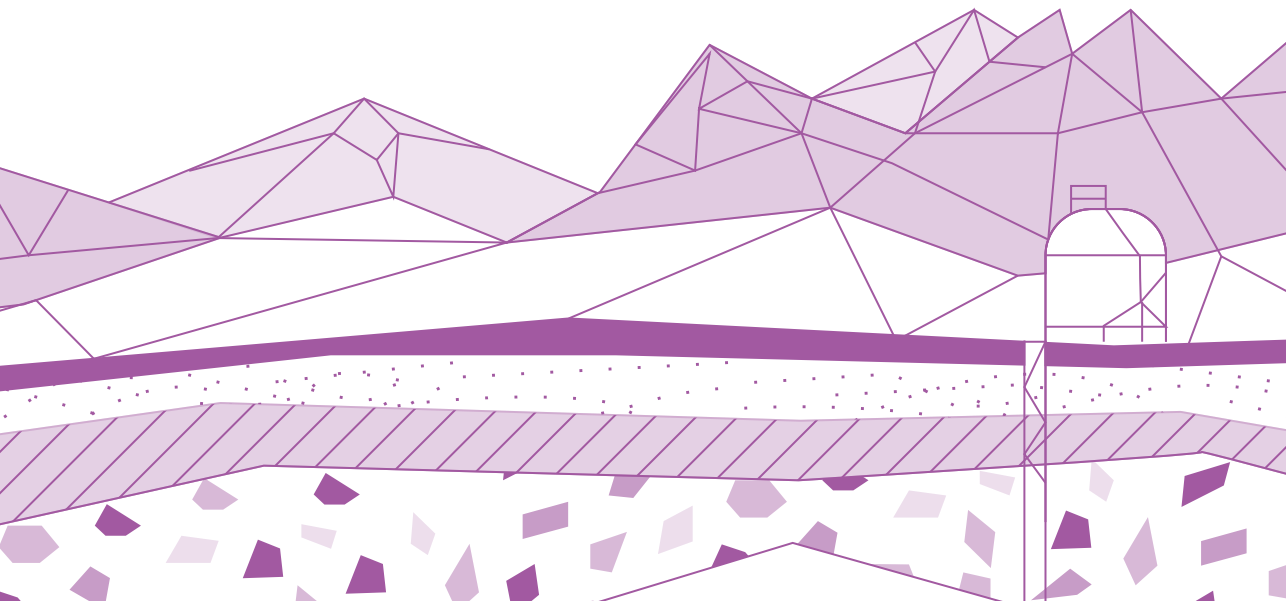
New uses of the underground environment for the energy and environmental transition require consideration of **factors that have so far received little attention** (for example, the geochemical or biological effects between fluids and rocks, or storage site integrity risks). The IFPEN Ressources Énergétiques Carnot Institute addresses these challenges with its underground modeling and simulation solutions.

These developments are based on the ARCANE open-source digital platform, co-developed with CEA-DAM as part of a process aimed at opening up to research players. Beyond these algorithmic solutions, this ambition is coupled with a data-driven approach via the implementation of AI-based solutions. In this context, the IFPEN Ressources Énergétiques Carnot Institute is leading a community of industrial geoscience players (the TELLUS community) **to develop innovative digital approaches**.

ENERGY STORAGE AND MANAGEMENT OPTIMIZATION

To support the growth in non-dispatchable energies and the increasing electrification of the economy, IFPEN is working in partnership with industry to develop energy storage and management technologies. IFPEN addresses the growing need for flexibility and stability in electricity networks with control and optimization software solutions involving battery storage and data processing. IFPEN develops multi-service EMS (Energy Management System) solutions and targets applications in the fields of individual or collective photovoltaic self-consumption and services for electricity networks (flexibility, peak shaving, reserve, etc.) involving batteries.





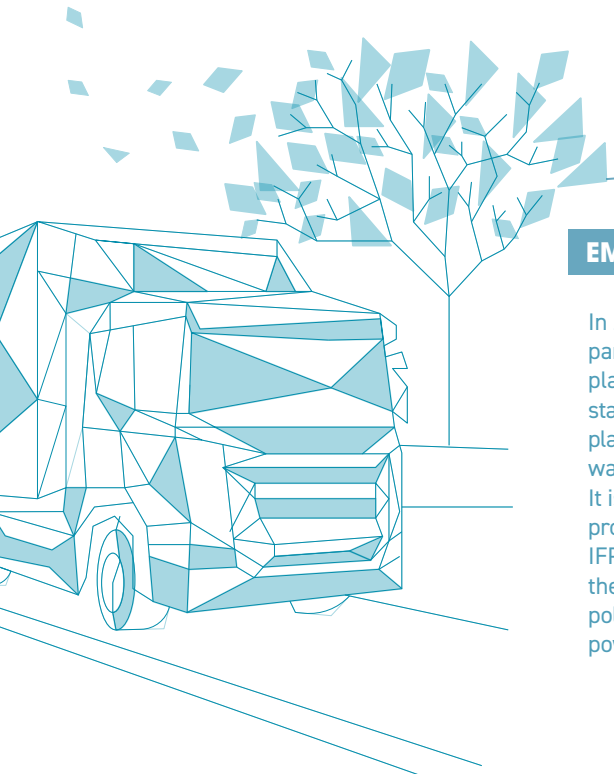
SUPPORTING THE MOBILITY TRANSITION

IFPEN is working to improve the environmental performance of mobility and diversify energy sources for clean, low-carbon mobility.

The decarbonization of the transport sector requires increased research in order to **further reduce the environmental impact of the technologies employed**, make use of cleaner energy sources such as electricity, biofuels, hydrogen and biogas and harness the optimization potential provided by digitalization.
To navigate this energy and ecological transition, which concerns the sector's players, local authorities and the public at large, IFPEN is mobilized in France and Europe via its Transports Énergie Carnot Institute.

CLEANER AND SMARTER TRANSPORT

To address the challenges of the ecological transition in the field of individual mobility and goods transport, public and industrial players and citizens need to be supported as they make decisions concerning the most appropriate technologies for these new demands. Such is the case, for example, for the introduction of low emission zones (LEZ) in France to address air quality problems in major cities. The IFPEN Transports Énergie Carnot Institute addresses these needs by conducting foresight studies. These studies combine different types of heterogeneous data to complete the missing data, as well as simulations to project the future. They also propose life-cycle analyses for a 360° vision. Such studies are often combined with web services to make them more dynamic, scalable and accessible to as many people as possible.



EMISSIONS ASSESSMENT

In 2024, **broader socio-economic studies were conducted**, particularly in the maritime sector. The creation of a platform for economic and environmental studies enabled standardization in the production of results. The R-TAMS platform for monitoring air quality linked to road transport was developed in 2024.
It is also the repository for the results of two European projects: OLGA for airports and MAGPIE for ports. Lastly, IFPEN was commissioned by the French Ministry for the Ecological Transition to carry out a study assessing pollutant emissions from trucks using different powertrain and fuel technologies.

INNOVATIVE SOLUTIONS FOR SUSTAINABLE ELECTRIC MOBILITY

Electrification represents one of the major levers to decarbonize the transport sector. IFPEN contributes by developing **technological and software solutions aimed at increasing the energy efficiency and reducing the environmental impacts** of transport propulsion systems. These innovative solutions can be developed for all mobility markets, whether for mass-produced cars, trucks, the off-road market, waterways or light and soft mobility.

119 MT CO_2

In 2024, the transport sector accounted for around 32% of all greenhouse gas emissions in France. More specifically, road transport was responsible for 119 Mt of CO_2.

"IFPEN works on the design of innovative electric machines for a broad power range (from 2 to 500 kW), their control electronics from 48 V to more than 800 V and for their associated control systems. In 2024, work on the design, validation and accreditation of a high-power low-voltage electric motor was completed, and the electric machine will be industrialized in 2025 by the partner."

Gaetano de Paola,
Program Manager

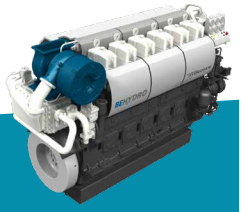
MORE EFFICIENT, SAFER AND MORE SUSTAINABLE BATTERIES

IFPEN also works on batteries, focusing **in particular on aspects relating to new materials, safety and recycling**. Numerous collaborative projects were launched in 2024. They concern new battery materials, the development of tools to investigate aging or safety for new battery chemistries, and an innovative methodology for the very rapid testing and sorting of battery cells with a view to their second life reuse. In addition, Axens began the process to set up a plant at Saint-Saulve (Hauts-de-France region of northern France) to synthesize cathode-active materials (CAMs) based on strategic metals from recycled batteries. In 2023, to support this industrial project, IFPEN initiated the MACADAMIA and RECORD projects, dedicated respectively to the production of new generations of cathode active materials and the recycling of strategic battery metals.

INNOVATING FOR HYDROGEN MOBILITY

Concerning hydrogen mobility, IFPEN is working on two complementary areas: **the use of hydrogen as a fuel and the fuel cell**. IFPEN's fuel cell research is mainly structured around two aspects: understanding and modeling the operation of fuel cells and the phenomena that lead to their aging, and the development of power electronics. These developments are carried out within the framework of industrial partnerships and collaborative projects benefiting from public funding.

The projects are conducted with industrial players, SMEs and French laboratories.



The PLH2 project demonstrated the feasibility of equipping trucks with hydrogen-powered combustion engines at a cost comparable to that of their diesel counterparts.

On its Solaize site, near Lyon, the IFPEN Transports Énergie Carnot Institute has been using a 210 kW test bench for fuel-cell systems since 2021. This experimental tool is the only one of its kind in France.

SUSTAINABLE FUELS: IFPEN ACCELERATES THE ENERGY TRANSITION

To decarbonize transport, **IFPEN develops processes for producing advanced biofuels and e-fuels from various renewable resources** (non-food biomass, low-carbon electricity and biogenic CO_2). These low carbon fuels are known as drop-in fuels, since they can be directly incorporated into fossil fuels without any changes to infrastructures or engines. To meet regulatory objectives, in particular those contained in the ReFuelEU Aviation initiative, IFPEN has developed several production technologies for sustainable aviation fuels, marketed by Axens, an IFPEN subsidiary:

- Vegan®, and hydroisomerization of lipid feestocks (vegetable oils, waste oils and animal fats);
- BioTfueL®, conversion of agricultural and forestry waste and residues into advanced biofuels using the thermochemical pathway, gasification process and the GASEL™ Fischer-Tropsch technology;
- Jetanol™, for the conversion of ethanol into biokerosene through the ATOL® dehydration technology, the Dimersol™, Polynaphta™ oligomerization technologies and hydrogenation. In Europe, the Futurol® technologies will be used for the production of advanced ethanol from lignocellulosic waste and residues.

IFPEN has developed four biofuels and e-fuels production processes based on a various range of resources adressing all mobility sectors (road transport, maritime and aviation).

REDUCING OUR ENVIRONMENTAL IMPACT

IFPEN's multi-disciplinary team of researchers has the ability to work on a wide range of projects to meet the needs of industry.

In 2024, IFPEN supported public authorities through several studies aimed at assessing CO_2 storage capacities at both national and European levels.

IFPEN: AN ACTIVE PLAYER IN THE DEVELOPMENT OF CO_2 CAPTURE TECHNOLOGIES

In line with the IPCC's call for immediate greenhouse gas emission reductions and the acceleration of CO_2 capture and storage, IFPEN contributes to the advancement of innovative CO_2 capture solutions.

"In 2024, two major milestones were reached with industrial-scale demonstrators. At the ArcelorMittal site in Dunkirk, the DMX™ process was successfully operated within the 3D/DinamX project, confirming its performance under real industrial conditions. In parallel, Chemical Looping Combustion (CLC) technology was demonstrated on lignite feedstock at a large unit in China, as part of the Sino-European CHEERS project. Beyond capture, IFPEN is also working on the conversion of CO_2 into e-fuels and e-products, opening new pathways towards sustainable energy and materials."

Kateryna Voronetska,
CCS & CCU
Program Manager

In 2024, Jeplan in Japan began intensive use of the innovative Rewind® PET demonstrator, which will produce high-quality recycled PET, identical to the pure material, from opaque and colored PET waste (bottles, multi-layer trays and textiles).

PLASTICS RECYCLING

IFPEN is present across the various advanced plastics recycling loops via the development of sustainable technology designed to convert plastic waste that cannot be addressed by mechanical recycling into high-quality recycled polymer materials. Alongside their partners, IFPEN's researchers develop innovative and economically viable technologies that can be used to process plastics as PVC, Polyolefins, used tires, textile and offer industry the solutions required to address society's increasing expectations in terms of reducing plastic waste in line with public circular economy policies.

More than 50 FTE are involved in this program. A new experimental platform, PROPRE is under finalization in the frame of State-Region funding program to provide suitable and flexible experimental tools to support R&D in this field.

SOIL ANALYSIS AND ENVIRONMENTAL MONITORING

The IFPEN Ressources Énergétiques Carnot Institute is developing technologies based on Rock-Eval® technology to characterize soil organic matter and carbon reliably and quickly. This research is conducted in line with the French national climate change adaptation plan (PNACC), which aims to strengthen the resilience of ecosystems (soils, forests, sea and coast, biodiversity, etc.) to enable them to adapt to climate change and extreme events. IFPEN is collaborating with national partners (INRAE, IRD, BRGM), notably through various public fundings projects, as well as with industrial players to validate its carbon analysis technologies and contribute to providing solutions for the ecological transition. The IFPEN Ressources Énergétiques Carnot Institute has also developed environmental monitoring tools to track polluting substances (Flair suite) and tested them under industrial conditions. Lastly, IFPEN is developing tools and knowledge for water resource management. The first aspect of this work relates to the optimization of the water cycle in industrial processes, particularly for the production of biofuels, green chemistry and the recycling of batteries, plastics and catalysts. The second component relates to the development of innovative solutions for the treatment of industrial pollutants, both traditional and emerging, such as microplastics and PFAS.

The Rock-Eval® analyzer is used to characterize carbon in soils.

TARGET

55%

The European Union aims to reduce its net greenhouse gas emissions by at least 55% by 2030, compared with 1990 levels, and to become carbon neutral by 2050.

Flair Suite, a range of connected tools for environmental and industrial gas monitoring

In order to monitor the chemical evolution of the atmosphere or track gases emitted from industrial sites into either the atmosphere or the soil, IFPEN's teams based in the Ressources Énergétiques Carnot Institute developed Flair Suite, a dedicated set of technological solutions. Made up of Flair car™, Flair box™, Flair soil™, Flair lab™ and Flair map™, the suite is designed to identify, quantify and map greenhouse gases and other gas pollutants in real time. The suite addresses various potential environmental, economic and safety issues in urban areas, on industrial sites and around natural sources.

FOCUS ON

SUPPORT FOR INNOVATIVE COMPANIES

For more than 30 years, IFPEN has been implementing a policy to support the technological innovation efforts of French SMEs and start-ups in order to make them more competitive and foster job and value creation.

R&I diagnosis: IFPEN offers an in-depth analysis to identify and prioritize the drivers of innovation surrounding the project leader's technology. This phase is aimed at defining a clear and operational R&I roadmap, in line with the project's objectives and challenges.

Proof of concept (POC): IFPEN evaluates the technical and economic viability of a technology, product or software that may be of interest to IFPEN's programs and activities.

Boost & Link: IFPEN co-develops or improves the innovative company's technology or process, drawing on its scientific and technical expertise or that of its partners. These collaborations can result in shared intellectual property.

Custom services
Technical and economic analyses, drafting of technical specifications, access to testing resources... IFPEN mobilizes its skills and tools to provide a targeted response to the specific needs of each project.

"We support innovative projects through each step of their technological development. Our offer is comprehensive, structured, scalable and results-oriented with a view to supporting and accelerating innovation."

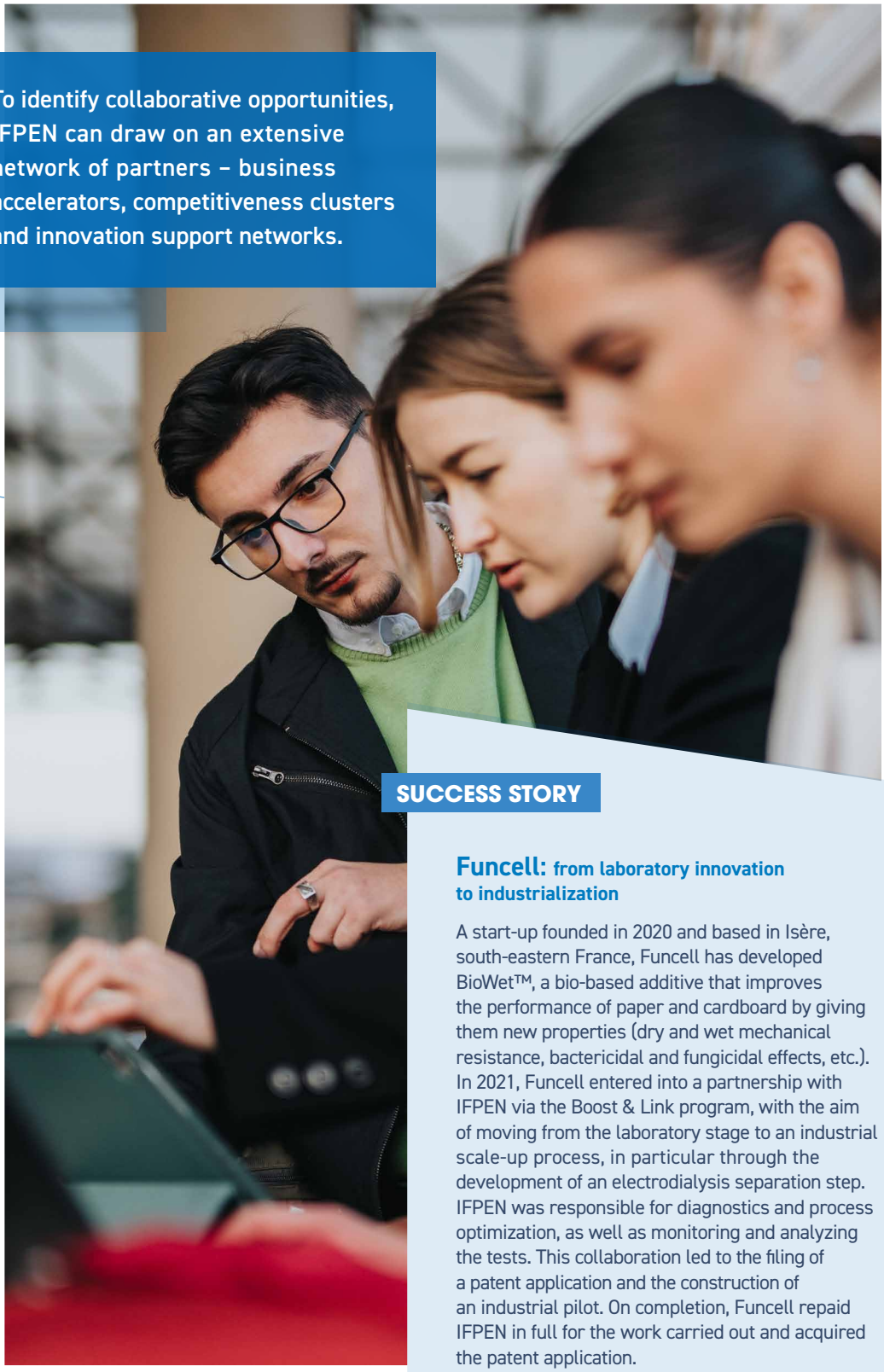
Bertrand Lecointe,
Open Innovation Manager at IFPEN

In 2024, IFPEN met more than 200 companies.

The projects of around 10 applicants for support are currently being examined.

With IFPEN, innovative start-ups and SMEs have access to 50 fields of expertise, 1,550 employees and 40 laboratories.

To identify collaborative opportunities, IFPEN can draw on an extensive network of partners – business accelerators, competitiveness clusters and innovation support networks.



SUCCESS STORY

Funcell: from laboratory innovation to industrialization

A start-up founded in 2020 and based in Isère, south-eastern France, Funcell has developed BioWet™, a bio-based additive that improves the performance of paper and cardboard by giving them new properties (dry and wet mechanical resistance, bactericidal and fungicidal effects, etc.). In 2021, Funcell entered into a partnership with IFPEN via the Boost & Link program, with the aim of moving from the laboratory stage to an industrial scale-up process, in particular through the development of an electrodialysis separation step. IFPEN was responsible for diagnostics and process optimization, as well as monitoring and analyzing the tests. This collaboration led to the filing of a patent application and the construction of an industrial pilot. On completion, Funcell repaid IFPEN in full for the work carried out and acquired the patent application.

IFP SCHOOL

TRAINING THE KEY PLAYERS IN THE ECOLOGICAL TRANSITION

Training, one of IFPEN's statutory missions, is provided by IFP School, the school for energy innovation and sustainable mobility.

IFP School, a graduate engineering institute and apprentice training center (CFA), trains the future players in the energy and environmental transition. It aims to address both the growing needs of industry and the expectations of society. To this end, the school provides world-class graduate programs in the fields of energy and sustainable mobility. These programs are based on innovative teaching methods, enabling students to develop the skills and expertise required to meet current challenges. The school also benefits from a solid network of academic and industrial partners, both in France and internationally, and conducts research activities within the framework of a strong corporate social responsibility approach.

FIGURES

52%

the proportion of IFP School students from outside France

27%

the proportion of women enrolled on IFP School graduate programs

TRAINING RESPONSIBLE ENGINEERS

At the interface between academia and industry, IFP School's mission is to provide young engineers with the skills and expertise needed to transform energy production, distribution and consumption systems. To this end, the school adopts a responsible and sustainable approach, incorporating practices that will enable future professionals to play an active role in the evolution of the energy sector.

Today, the training provision includes 20 programs leading to Master's level degrees, 12 of which are taught in English.

A third of recent graduates are now working for companies involved in green technologies, in areas such as sustainable mobility, the energy economy, chemistry and georesources.

INNOVATIVE TEACHING SERVING INDUSTRY

IFP School's teaching approach is grounded in innovation and agility. The programs are regularly revised and adjusted to meet industry requirements and enable students to become immediately operational. The emphasis is on solving real-life problems using methods that encourage learning through experience. Tools such as serious games, design thinking and immersive realities encourage the acquisition of professional skills and appropriation of the future work environment.

These teaching tools are combined with practical work using real industry data, as well as field placements. The school also makes use of Lab e.nov™, its digital culture laboratory, which supports initiatives in teaching and innovation. By way of illustration, two new virtual reality modules, "Electric Bench Lockout" and "Electric Machine", as well as workshops aimed at developing the AI experience of teachers, were rolled out in 2024.

In 2024, IFP School was recognized for the quality of its student experience, ranked 4th among engineering schools in France offering the best experience for women, according to the 2024 HappyAtSchool®/Focus Women ranking.

This distinction reflects the school's commitment to providing a high-quality environment for all its students. The School also ranked in the top 10 for CSR, highlighting its commitment in this area.

CONTINUOUS DEVELOPMENT OF THE TRAINING OFFER

In 2024, the training provision was expanded to better meet the growing skills needs associated with the energy and ecological transitions. A new Mastère Spécialisé® program dedicated to hydrogen project engineering was launched. The first student intake began the program in September 2024. In addition, three further programs will begin in September 2025: two graduate engineering programs in "Offshore Wind Project Development" and "Electricity Management and Digital", and a Mastère Spécialisé® in "Energy and Carbon Management in Business". At the same time, the school had accreditation for its existing programs renewed by the French National Engineering Accreditation Board (CTI). This accreditation guarantees the quality and relevance of the training offer.

IFP School is

1 specialized engineering school (for candidates with a 4 or 5-year university degree and professionals)

3 MOOCs
Energy Transition: Innovation Towards a Low-Carbon Future; Hydrogen Production; Hydrogen for Mobility

1 digital culture laboratory, Lab e.nov™

4 teaching and research chairs (CarMa, EleTher, ECAV et EDT)

>500 graduates/year, 40 nationalities

20 degree programs

+16,000 alumni active in more than 100 countries

To find out more, go to www.ifp-school.com

IFPEN IN FIGURES

1,543
TOTAL FTE*
for 2024

including
1,087
RESEARCHERS AND R&I TECHNICIANS

** Full-time equivalent*

190
PHD STUDENTS, POST-DOCTORAL RESEARCHERS AND PLACEMENT STUDENTS

36
WORK-STUDY STUDENTS

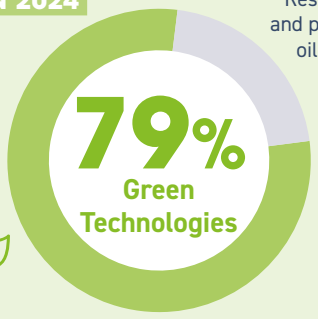
€122.2 million
BUDGET ALLOCATION

€154.4 million
OWN RESOURCES

€291.8 million
OPERATING EXPENSES
including
€245.5 million
FOR R&I

SHARE OF GREEN TECHNOLOGIES IN R&I IN 2024

21%
Responsible and profitable oil and gas



FRANCE 2030

IFPEN is leading the **MOBIDEC PEPR*** (dedicated to the digitalization and decarbonization of mobility – low-carbon mobility) and co-leading the **B-BEST PEPR** (dedicated to bio-based products and sustainable fuels) and the **SPLEEN PEPR** (dedicated to the decarbonization of industry). IFPEN is also involved in **four further PEPRs** associated with the French National Acceleration Strategy or PEPR-SNAs (Batteries, Recycling, Low-carbon H_2 and Advanced Energy System Technologies (TASE) and contributing to **six exploratory PEPRs**: SousSol, OneWater, FairCarboN, NumPex, Maths-Vives and DIADEM.

** French priority research programs and equipment initiatives*

2 CARNOT

THE IFPEN TRANSPORTS ÉNERGIE CARNOT INSTITUTE
(since 2006)

THE IFPEN RESSOURCES ÉNERGÉTIQUES CARNOT INSTITUTE
(since 2019)

ISO 9001 certification for its R&I activities and **ISO 50001 certification** for its activities devoted to energy efficiency.

PATENTS

127 FIRST PATENT APPLICATIONS FILED

Of which **111** IN THE FIELD OF GREEN TECHNOLOGIES

Chemical or biological plastics recycling

Period 2010-2019

1st LEADING GLOBAL RESEARCH CENTER

Hydrogen technologies

Period 2011-2020

2nd GLOBAL RESEARCH CENTER

Low-carbon technologies

Period 2000-2019

4th GLOBAL RESEARCH CENTER

Leader in the fields of CCUS and alternative fuels

Electric networks

Period 2011-2022

9th PATENT FILER

Leader for stationary storage

SUBSIDIARIES AND SHAREHOLDINGS

Pivotal to IFPEN's development policy, IFPEN group brings together leading industrial players worldwide and young innovative companies. The stature and profile of the former, combined with the promising potential and dynamism of the latter, reflect the capacity of this policy to create value and jobs. IFPEN's portfolio of subsidiaries and shareholdings is held either directly or indirectly via its subsidiary IFP Investissements, which is itself 100% owned by IFPEN.

Eco-energies & mobility

- 75% GreenWITS
- 24% DRIVE QUANT
- 18% la Cie des Mobilités
- 11% K-Ryole
- 11% so sponge
- 6% Tec E Mouv

Oil and gas processes & products, biomass, water, CO_2, materials recycling

- 99% Axens
- 16% nacre
- 10% BioTJet

Consultancy & software in the field of geosciences

- 100% BeicipFranlab
- 100% TECHI advantage

Training

- 62% IFP Training

THE EXECUTIVE COMMITTEE

AS OF 1 JULY 2025

GENERAL MANAGEMENT

Pierre-Franck Chevet
Chairman and CEO

Cécile Barrère-Tricca
Executive Vice-President, responsible for innovation and economic development

Benjamin Herzhaft
Executive Vice-President, responsible for research and training

COMEX MEMBERS

Emmanuel Manceau
Director of the Energy Systems Business Unit

Raphaël Huyghe
Director of the Energy Products Business Unit

Arnaud Baudot
Director of the Chemistry for Industry Business Unit

Gaëtan Monnier
Director of the Mobility Business Unit

Nathalie Alazard-Toux
Director of the Industrial Development Business Unit

Pascal Longuemare
Director of the Education & Training Business Unit

Florence Delprat-Jannaud
Scientific Director

Anne-Karine Feyel
Human Resources Director

Dominique Humeau
Director Digital Science and Technology, Digital and Information Systems

IFPEN's main strategic directions and annual activity program are approved and monitored by the Board of Directors, which is assisted by several consultative bodies: the Scientific Board, four Industrial Committees, the Stakeholders' Committee and the IFP School Advisory Board. A list of the members of each of these bodies is available at **www.ifpenergiesnouvelles.com**

TO KEEP UP TO DATE WITH THE DAILY NEWS AT IFPEN

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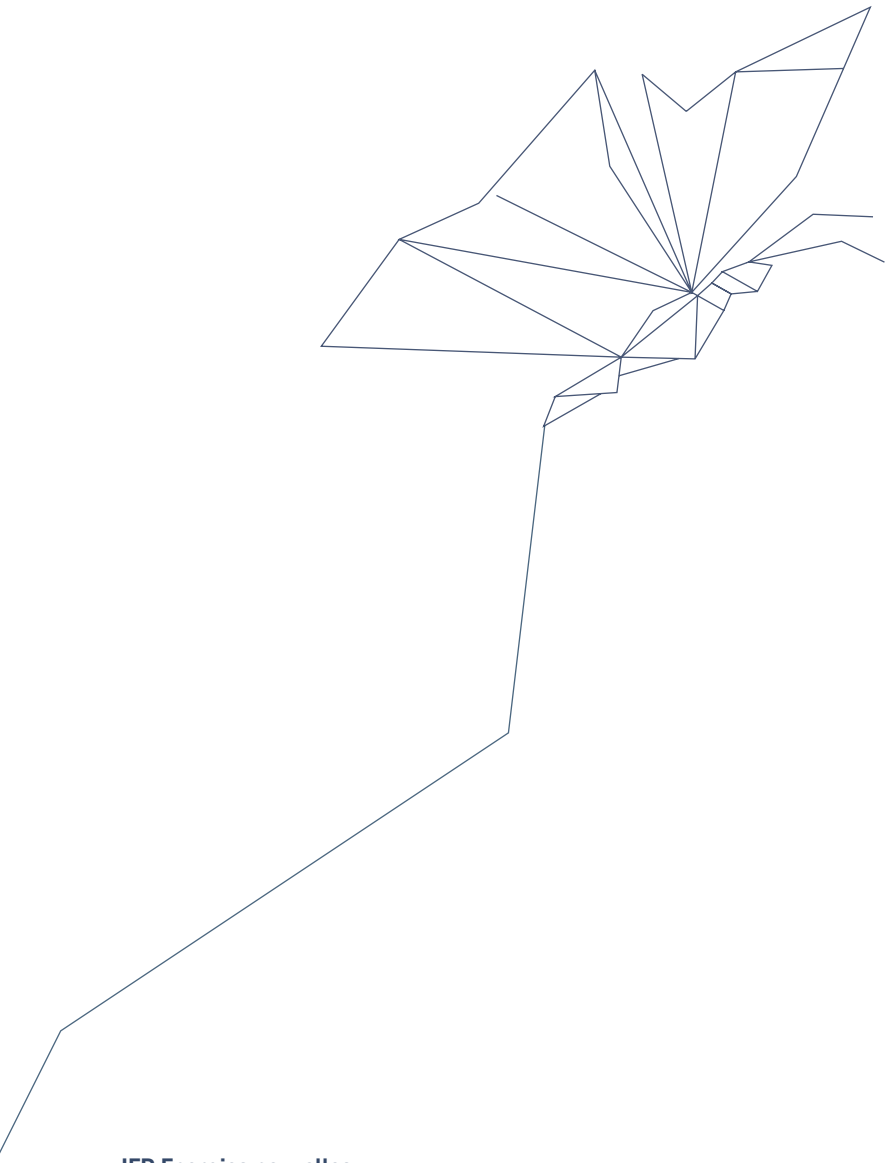

IFP Energies nouvelles
1 et 4, avenue de Bois-Préau
92852 Rueil-Malmaison Cedex
Tel.: +33 1 47 52 60 00

IFP Energies nouvelles Lyon
Rond-point de l'échangeur de Solaize
BP 3 – 69360 Solaize
Tel.: +33 4 37 70 20 00

www.ifpenergiesnouvelles.com