



THE ESSENTIALS

+

INNOVATING
FOR ENERGY

2020



INTERVIEW WITH PIERRE-FRANCK CHEVET CHAIRMAN AND CEO OF IFPEN



IFPEN, INNOVATION ACCELERATOR

Despite a year marked by significant restrictions, we have managed to maintain a steady course. IFPEN's teams have rallied to drive forward our research and meet their commitments to our partners and subsidiaries. With 67% of our activities related to new energy technologies, IFPEN already focuses a significant share of its research efforts on the energy transition. We are now accelerating, targeting the ecological transition.



+

IFP Energies nouvelles (IFPEN) is a major research and training player in the fields of energy, transport and the environment. From scientific concepts within the framework of fundamental research, through to technological solutions in the context of applied research, innovation is central to its activities, hinged around four strategic priorities: climate, environment and circular economy – renewable energies – sustainable mobility – responsible oil and gas.

As part of the public-interest mission with which it has been tasked by the public authorities, IFPEN focuses its efforts on bringing solutions to take up the challenges facing society and industry in terms of energy and the climate, to support the ecological transition. An integral part of IFPEN, IFP School, its graduate engineering school, prepares future generations to take up these challenges.

Applied research programs are structured around four strategic priorities:

- climate, environment and circular economy: reducing the impact of human and industrial activities on the climate and the environment;
- renewable energies: producing energy, fuels and chemical intermediates from renewable sources;
- sustainable mobility: developing efficient, environmentally friendly solutions for the transport sector;
- responsible oil and gas: meeting the demand for energy and chemical products in a more environmentally-friendly manner.

IFPEN thereby contributes to the creation of value by supporting French and European economic activity and the competitiveness of industrial sectors related to mobility, energy, and eco-industry.

OUR MISSION

BACKGROUND
CLIMATE CHANGE
AND ECOLOGICAL TRANSITION

+ **CHALLENGES**



**FOSTERING SUSTAINABLE
MOBILITY**



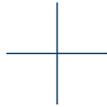
**DIVERSIFYING
THE ENERGY MIX**



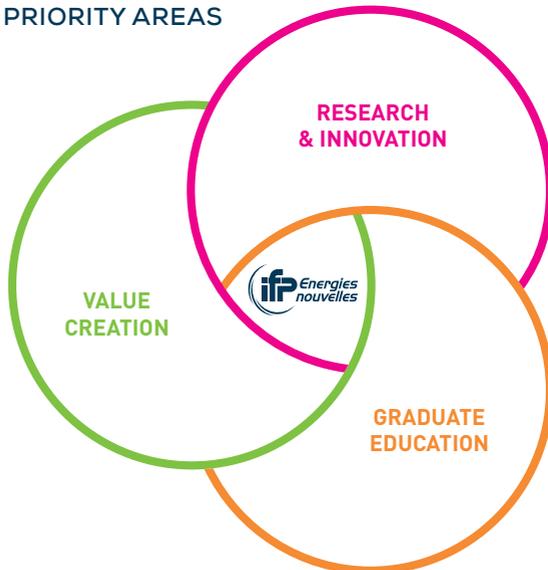
**INCREASING ENERGY
EFFICIENCY**



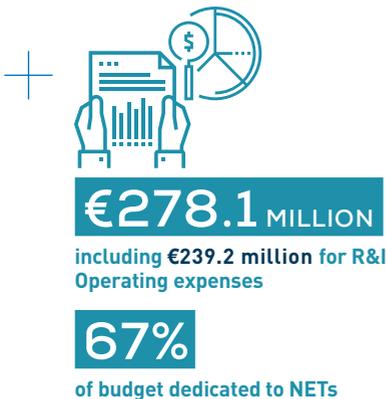
**REDUCING THE ENVIRONMENTAL
IMPACT OF FOSSIL RESOURCES**



+ **3 PRIORITY AREAS**



KEY FIGURES



2

Carnot Institutes:
the IFPEN Transports Energie
Carnot Institute and the IFPEN
Ressources Énergétiques
Carnot Institute



ISO AWARDED
ISO 9001
for its R&I activities

175
basic patent applications,
including
105
in the field of NETs

More than
500
IFP School graduates

43 000
masks supplied to medical
facilities in March 2020



DEVELOPING TODAY THE INNOVATIONS OF TOMORROW



CLIMATE, ENVIRONMENT AND CIRCULAR ECONOMY

A major player in the ecological transition and the circular economy, IFPEN develops solutions aimed at limiting the impact of human and industrial activities on the climate and environment. Teams conduct research in the fields of the chemical recycling of plastics, CO₂ capture and storage and climate/soil interactions and develop air quality prediction models. IFPEN also evaluates opportunities in new areas, such as lithium recovery and the recycling of used catalyst metals.



RENEWABLE ENERGIES

Tackling climate change and moving the energy sector to a sustainable, low-carbon and cost-effective energy mix require technological innovations. IFPEN is contributing to this transformation by developing production processes for advanced biofuels and sustainable bio-based products. The IFPEN Ressources Énergétiques Carnot Institute is also working on the development of ocean energies and energy storage solutions, among others.

+ SUSTAINABLE MOBILITY

The climate and environmental emergency requires significant mobilization around the challenges of sustainable mobility. To assist local authorities in their decision-making processes for their mobility plans, support citizens towards more eco-responsible behavior and help companies develop disruptive innovations, the IFPEN Transports Energie Carnot Institute is exploring three technological avenues: electric mobility, connected mobility and mobility with a low environmental impact.



+ RESPONSIBLE OIL AND GAS

IFPEN, committed to supporting a sustainable energy mix, works on solutions aimed at reducing the environmental footprint of the industry and the transport sectors. For example, the research teams develop eco-efficient and flexible processes for the production of fuel and chemical intermediates meeting the strictest standards. To make better use of resources, IFPEN also proposes increasingly clean and efficient cutting-edge technologies for oil and gas exploration and production.



FUNDAMENTAL RESEARCH SERVING INNOVATION

In order to support its innovation ambitions and ensure the scientific excellence of its research activities, IFPEN relies on a collaborative fundamental research program, organized around nine scientific challenges. This approach, initiated five years ago, has demonstrated its relevance and effectiveness, and efforts to optimize it continued in 2020. Better targeted, the scientific questions raised have more effectively supported the projects for new products and processes development within the framework of IFPEN's major strategic priorities.

ENCOURAGING AND SUPPORTING INNOVATION



IFPEN contributes to the development of green industrial sectors and sustainable mobility, speeding up the detection of new energy technology opportunities. To this end, a diversification process is under way concerning industrial partnerships, innovation support for SMEs and startups and the development of IFP group subsidiaries. Underpinning this, IFPEN encourages the expression of a genuine in-house culture of innovation.



TO STIMULATE INTERNAL INNOVATION IN THE NET FIELD

IFPEN set up a project incubator aimed at facilitating the maturation of new ideas to support the ecological and energy transition. In addition, a biennial innovation challenge for employees, IFP School students and subsidiary employees stimulates the emergence of new ideas via the pooling of skills. Moreover, a “free creativity” initiative operates alongside those described above, encouraging ideas focusing on the development of new skills, methodologies and experimental and numerical tools.



START-UP AND SME SUPPORT

IFPEN has been actively supporting SMEs and intermediate-sized companies for nearly 30 years. Today, this support extends to start-up companies and is primarily focused on the energy transition and the environment. To improve the detection of opportunities, IFPEN draws on an extensive network of partners.



MOVING TOWARDS NETS: SUPPORTING THE GROUP SUBSIDIARIES AND STAKEHOLDINGS

IFPEN's technology transfer policy is underpinned by its dynamic portfolio of subsidiaries and stakeholdings, today bringing together reference global industrial players and newly created innovative companies. Hence, in line with R&I activities, the group's subsidiaries are pursuing their NET development.

TRAINING TALENTED YOUNG PEOPLE FOR THE ENERGY TRANSITION



IFP School prepares its students for the professions of today and tomorrow in the fields of energy and sustainable mobility. Its programs, based on an innovative teaching model, are aimed at supporting the ecological transition by training talented young people in technological innovations, addressing society's expectations and industry's needs. The School is supported by an extensive network of national and international academic and industrial partners.



MAKING THE ENERGY TRANSITION A SUCCESS

IFP School is constantly adapting its graduate programs to reflect the evolving needs of industry and society, incorporating new themes relating to the ecological transition and digitalization. The provision includes ten programs leading to specialized engineering degrees, six of which are taught in English, three research-oriented master's programs, two specialized master's programs and an executive program, covering four fields: powertrains and sustainable mobility, energy economics and management, processes for energy and chemistry, georesources and energy.



AGILE LEARNING FOR A RESTRICTIVE CONTEXT

2020 saw an acceleration in the digitalization process underway at IFP School; the successful transformation of a graduate school to the agile and innovative educational model now in place ensured the continuity of its course programs, driven by the new innovation and digital culture laboratory (LAB e.NOV™) and thanks to the commitment of all of the School's personnel. In concrete terms, programs were completely reorganized for delivery remotely or in hybrid mode (remote and on-site) whenever the context demanded, with numerous courses adapted to digital format and the development of virtual reality modules. In addition, the implementation of an immersive digital twin of a powertrain demonstration room facilitated the acquisition of advanced technical skills. This new digitalized environment also facilitated student integration and encouraged teamwork and mutual support between students present on-site and those studying remotely, fostering a community spirit that perfectly reflects one of the School's values: solidarity.

IFPEN NEWS IN 2020: PANORAMA



IFPEN COMMITTED TO SUPPORTING THE DEPLOYMENT OF HYDROGEN

In 2020, IFPEN, already active in some of the technological building blocks of the hydrogen value chain, drew up a road map to consolidate its positioning and appointed a hydrogen coordinator. He addressed the French Commission for Energy Regulation and the Parliamentary Office for the Assessment of Scientific and Technological Choices (OPECST) regarding the conditions that need to be met to economically deploy low-carbon hydrogen in the various sectors. An industrial chair, Orhyon (focusing on micro-organisms and hydrogen reactivity in the underground environment), selected by the ANR, was launched in November. It will help provide a better understanding of the mechanisms governing hydrogen mobility and reactivity in geological formations. The use of hydrogen in transport, notably via the hydrogen fuel cells and IC engine solution, is also the focus of research.



COVID-19 : IFPEN ADAPTS AND ENGAGES

In response to Covid-19, IFPEN has adapted the way it organizes its activities in order to protect its employees and partners. At the end of February, a crisis unit was activated and began holding daily meetings. A business continuity plan was drawn up in order to help IFPEN and its employees be as well prepared as possible to deal with the situation. IFPEN soon began using its 3D printers to produce protective visors for neighboring hospitals. It also donated most of its stocks of masks and gowns to hospital or community health workers. On 11 May, priority experimental activities were gradually resumed at both sites. Reinforced protective measures were put in place for the staff present, but most employees continued to work from home until mid-June. It is important to note that IFPEN's digital transformation initiated a few years ago made it much easier to ensure business continuity.



CATHERINE RIVIÈRE APPOINTED TO THE FRENCH NATIONAL AIR COUNCIL



On 31 January 2020, by order of the French Minister for the Ecological and Inclusive Transition, published in France's Official Journal of 16 February, Catherine Rivière, Executive Vice-President responsible for Research and Innovation, was appointed to the French National Air Council as IFPEN representative.



GENERATE PROJECT

In June 2020, IFPEN and the French Institute for International and Strategic Relations (IRIS) published a review of the research conducted within the framework of the Generate (Geopolitics of renewable energies and prospective analysis of the energy transition) project, financed by the ANR (see page 21). This research continued with a geopolitical analysis of reliance on metals conducted by IFPEN (see page 13).



INRIA AND IFPEN SIGN A PARTNERSHIP AGREEMENT SERVING THE ENERGY TRANSITION

In June 2020, Pierre-Franck Chevet and Bruno Sportisse, Chairman and CEO of Inria, signed online a new framework strategic partnership agreement to support the energy transition. Alongside the joint work conducted in the fields of numerical simulation and high-performance computing since 2015, when the first framework agreement was signed, this recent agreement paves the way for new collaborative research avenues focused on artificial intelligence (AI) and high-performance data analysis technologies. One of the main goals is to help meet the objectives of France's national low-carbon strategy (SNBC). This partnership thus covers five new themes for which road maps have been drawn up jointly by IFPEN and Inria: modeling and monitoring of offshore wind turbines, molecular simulation in the field of catalysis, numerical reduction of complex models for simulation, 4D modeling in the field of geosciences, knowledge management and AI-assisted information search.



EMISSIONS FROM RECENT GASOLINE AND DIESEL VEHICLES: PUBLICATION OF THE STUDY CONDUCTED BY IFPEN

In July 2019, the IFPEN Transports Energie Carnot Institute joined forces with the French Ministry for the Ecological Transition (MTE) to launch a scientific study aimed at providing a transparent evaluation of the real-use environmental performance of gasoline and diesel cars (Euro6d-Temp) currently on the market. This study, which falls within the scope of IFPEN's role as a provider of expertise to public authorities, focused on the local greenhouse gas and pollutant emissions of a panel of 22 vehicles representative of the models sold in France. The IFPEN Transports Energie Carnot Institute, an expert in the characterization of vehicle pollutant emissions, was responsible for proposing technical protocols, organizing and conducting experiments, and analyzing and summarizing results. The study report was published in December 2020. It was presented by Pierre-Franck Chevet to the automobile and mobility sector strategic committee, chaired by Luc Chatel, in the presence of Agnès Pannier-Runacher, deputy minister representing the Minister for the Economy, Finance and Recovery, responsible for Industry. In parallel, the results were presented to the NGOs France Nature Environnement, Transport & Environnement, Nicolas Hulot Foundation and Réseau Action Climat (Climate Action Network). The protocol and study report are available on the www.ifpenouvelles.com website.



IFPEN AND UNESCO JOIN FORCES IN THE FIELD OF GEOSCIENCES

IFPEN and Unesco signed a framework partnership agreement in the field of geosciences related to sustainable resource management supporting the energy transition. Firstly, the agreement concerns research and training in the area of earth sciences, proposing thesis topics related to the geological storage of CO₂ and hydrogen, geothermal energy, the use of underground resources and the understanding of the interactions between climate changes and ecosystems from the study of sedimentary systems. Secondly, it promotes digitalization in geosciences, particularly hinged around digital tools developed by IFPEN that could be rolled out in Unesco Global Geoparks, with a dual objective: to educate, but also to evaluate and enhance these applications drawing on a participative science approach.

CLIMATE, ENVIRONMENT AND CIRCULAR ECONOMY

CO₂ CAPTURE

LAUNCH OF DINAMX, AN INDUSTRIAL PILOT DEMONSTRATION PROJECT FOR THE IFPEN DMX™ PROCESS

The four-year DinamX “Demonstration and INnovative Applications of the DMX™ process” investment for the future project was launched with partners IFPEN, Axens, Total and ArcelorMittal France. The DMX™ process will initially be demonstrated on the pilot unit built and financed for the 3D project, at ArcelorMittal’s site in Dunkirk. Coordinated by Axens, the aim of the DinamX project is to support the demonstration of the IFPEN DMX™ process, designed to capture carbon dioxide from blast furnace gases, and evaluate possible application to emitters other than the steelmaking industry addressed in the European H2020 3D project.

CLIMATE/SOIL INTERACTIONS



Violaine Lamoureux-Var, winner of the FIEEC Carnot award for Rock-Eval® 7S.

The 7th generation of the Rock-Eval® technology with rapid assessment of carbon and sulphur compounds was launched to market. In November, Violaine Lamoureux-Var won the 2020 FIEEC Carnot Applied Research award for research conducted with SME

Vinci Technologies relating to the development of Rock-Eval® 7S. The award is given in recognition of research developed with an SME with a genuine impact on growth and job creation. This thermal geochemical analysis technology, initially designed for rock evaluation, is the focus of research work to characterize organic carbons and contribute to the evaluation of the quality and fertility of soils and their role in climate regulation.

AIR QUALITY

WITH GECO™ AIR, IFPEN IS AT THE FOREFRONT OF PROJECTS SUPPORTING THE REGIONS

Via the Airmes, Capture and Reveal projects, funded by Ademe, IFPEN is continuously enhancing Geco™ air, its online tool used to estimate the pollutant footprint of an infrastructure and provide maps of road-related pollutant emissions. In 2020, a new project - Acacias - was one of those selected within the “Primequal” call for research proposals for better air quality, also launched by Ademe. The purpose of Acacias is to develop new methodologies enabling towns and cities to identify and promote public policies linked to the most environmentally-friendly mobility options. The project combines household mobility surveys with behavioral data collected by Geco™ air.

CHEMICAL RECYCLING OF PLASTICS

DEVELOPMENT OF AN INNOVATIVE PET WASTE RECYCLING PROCESS

Axens, IFPEN and Jeplan signed a partnership agreement to develop, demonstrate and market Rewind™ PET, an innovative PET recycling process based on depolymerization for all types of PET waste, including bottles, films, containers and textile (polyester).

The three partners, who have pooled their operational, engineering and technological knowledge, will be using Jeplan's demonstration plant in Japan to accelerate the development and demonstration of their joint process.

Thanks to the research conducted at IFPEN's facilities in Lyon and the demonstration unit, the partners are targeting the exclusive global marketing by Axens of the Rewind™ PET process by the end of 2022.



CRITICAL METALS AND RARE EARTHS

CRITICAL METALS IN THE ECOLOGICAL TRANSITION

Following on from the ANR Generate project, the results of which were published in May 2020 (*see page 21*), IFPEN's Economics and Environmental Evaluation Department is pursuing and reinforcing its prospective research activities. In particular, the team is evaluating the demand for materials in the energy transition out to the year 2050 as a function of different scenarios (2°C and 4°C), incorporating hypotheses regarding different types of mobility (“sustainable” and “business as usual”) and recycling. Modeling research conducted with the TIAM-IFPEN model provides information about the geological, economic, geostrategic, social and environmental risks to which the most critical metals (cobalt, copper, rare earths, lithium and nickel) are exposed in order to shed clear light on the geopolitical situation that may arise in a context in which renewable energies and electric mobility consume a high volume of resources. The conclusions are the focus of a series of articles in international journals, as well as short articles, podcasts and videos available on the IFPEN website.

RENEWABLE ENERGIES

BIOFUELS

BIOTFUEL®: SUCCESS OF TORREFIED BIOMASS GASIFICATION

Tests involving the gasification of torrefied biomass were successfully conducted by the consortium* as part of the finale demonstration phase for BioTfuel® technology, aimed at producing biokerosene and biodiesel from lignocellulosic biomass. Around 170 tons of torrefied biomass produced on a pretreatment demo plant were gasified over more than 100 hours of continuous operations. Tests will continue in 2021 for various biomasses. This final project demonstration phase will be used to validate the overall efficiency of the process chain, prior to marketing.

* IFPEN, Avril, Axens, CEA, Thyssenkrupp Industrial Solutions, Total.

OFFSHORE WIND AND OCEAN ENERGIES

BEST PERFORMANCE FOR IFPEN IN THE BENCHMARK PROPOSED BY THE IEA WIND PROGRAM

Within the framework of the International Energy Agency's partnership program relating to wind turbine technologies, IEA Wind, several research laboratories addressed the complex problem of the positioning of around 80 wind turbines on an offshore wind farm, with a view to maximizing production. The case study, involving five pre-defined zones, illustrated an offshore wind park currently being deployed in the Netherlands. Representative wind conditions for a year were supplied, as well as the wake effects between wind turbines. The solution proposed by the IFPEN Ressources Energétiques Carnot Institute obtained the best score, delivering a higher annual electricity production than that of its competitors.





BIO-BASED CHEMISTRY

LAUNCH OF AN AMBITIOUS GREEN CHEMISTRY PROJECT

Cargill, IFPEN and Axens joined forces to launch a project for the development and industrial scale-up of a catalyst and process for the conversion* of a lactic acid into a bio-based acrylic acid of plant and renewable origin. The use of this raw material that is contained in numerous everyday products, such as acrylic glass, adhesives and super-absorbent polymers, will contribute to the development of the bioeconomy and lead to a reduction in greenhouse gas emissions of more than 50%.

** Using a technology developed in the laboratory by Procter & Gamble and for which Cargill obtained an exclusive license at the beginning of 2020.*



Interview with:
Vincent Coupard,
bio-acrylic acid project manager

The catalyst and process we are going to develop with our partners are based on a conversion technology that has already been tested in the laboratory. However, a number of significant challenges still need to be overcome prior to industrial scale-up. Each partner will have a decisive role to play: Cargill will contribute its experience in the field of bio-based materials, IFPEN will draw on its expertise to develop the catalyst and the conversion process required for the large-scale transformation of lactic acid into bio-based acrylic acid, and Axens will facilitate industrial scale-up in line with existing environmental standards.



ENVIRONMENTAL MONITORING



FLAIRSUITE: INDUSTRIAL AND ENVIRONMENTAL MONITORING SERVICES

The IFPEN Ressources Énergétiques Carnot Institute is developing a comprehensive offer dedicated to the measurement and analysis of gas compositions in the air and soil for industrial and environmental monitoring applications. FlairSuite consists of mobile or fixed measurement equipment, laboratory instruments and a data processing, visualization and storage tool: FlairBox™, mobile multi-gas air and soil analysis station; FlairCar™, autonomous mobile multi-gas air analysis station; FlairSoil™, fixed multi-gas soil and underground analysis station; FlairLab™, gas laboratory for complementary studies; and finally FlairMap™, interactive data processing web application.

SUSTAINABLE MOBILITY

ELECTRIC MOBILITY

THE EFFORTLESS TRANSPORT OF HEAVY LOADS IN HOSPITAL: FIRST PROTOTYPES FOR OWLONE™



OwlOne™ represents the culmination of one of the six winning projects in IFPEN's internal innovation challenge selected in April 2018. It is designed to make it easier to transport heavy loads in hospitals, thereby reducing musculoskeletal problems among personnel. Having developed an economic model and analyzed market provision, 2020 saw the preproduction of five prototypes. The next step will consist in setting up a company to take this innovative solution to market (see page 22).

H2020 MODALIS² PROJECT



Interview with:

Martin Petit, research engineer and Modalis² project coordinator

At the beginning of 2020, the H2020 Modalis² "MODelling of Advanced LI Storage Systems" project was launched for a period of three years. Led by IFPEN alongside nine other academic and industrial partners (the Fiat research center, Siemens Digital Industries Software, Gemmate Technologies, K&S, Saft, Siemens Corporate Technologies, Solvay, Turin University and Umicore) Modalis² is aimed at developing a chain of numerical tools making it possible to model and design battery systems using new materials such as alloys with silicon for negative electrodes, solid electrolytes, etc. Using this new modeling approach,

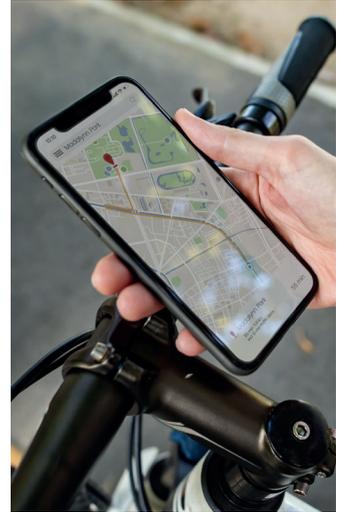
battery development costs, as well as the costs of component materials, could be reduced by between 20% and 35%. By decreasing the time-to-market of new-generation batteries, it is possible to significantly reduce their cost price. This is the challenge we are trying to overcome via Modalis², with the expectation that this project will reinforce the European battery production industry.



CONNECTED VEHICLES

CREATE YOUR OWN MOBILITY APPS USING XDASH™!

xDash™ is an open-access software platform developed by teams from the IFPEN TE Carnot Institute enabling researchers who are not specialists in web technologies to easily build their own web applications. Originally designed for the development of web applications related to mobility, xDash™ has now been adapted to meet any type of need. Users have access to algorithms developed by IFPEN or other research bodies relating to a variety of topics, including weather, road traffic, Covid, etc. In order to meet the needs of engineers and scientists, since 2020, it has been possible to write or directly import Python code in xDash™. Python code is widely used in data science. Moreover, hosted in SaaS mode on Microsoft's Azure servers, it can be deployed in accordance with the security rules demanded by SaaS-type software and be interfaced with customer web services.



IC POWERTRAINS

THE EUROPEAN EAGLE PROJECT PAVES THE WAY FOR A HIGHLY EFFICIENT GASOLINE ENGINE

The "Efficient Additivated Gasoline Lean Engine" project, coordinated by IFPEN and conducted with eight partners* ended at the beginning of 2021. The aim of the project was to develop a spark ignition gasoline engine for a hybrid application delivering peak efficiencies of 50% while reducing emissions. Several pioneering technologies, such as hydrogen injection, a pre-chamber ignition system for ultra-lean operations and the recourse to new smart coating materials for thermal insulation were experimentally evaluated and demonstrated promising results. The tests conducted on a multi-cylinder Renault engine also validated the innovative two-stage electric turbocharging system and clarified the understanding of the after-treatment system required to obtain ultra-low exhaust gas pollutant emissions.

**Renault, Vitesco Technologies (Germany and France), FEV Europe GmbH, Saint-Gobain, alongside the Universities of Naples, Aachen and Valencia*

FOCUS

The hydrogen IC engine represents a solution helping to achieve clean and decarbonized mobility in that hydrogen combustion only produces water and very small quantities of nitrogen oxides (NOx). It is considered to be an alternative to the fuel cell for some usages and has the advantage of using the same production facilities as those employed for existing IC powertrains. This solution, which requires specific powertrain adaptations to obtain a high level of efficiency and low NOx emissions, is the focus of research and advanced tests currently being carried out by teams at the IFPEN TE Carnot Institute, some in collaboration with industrial partners.

RESPONSIBLE OIL AND GAS

FUEL PRODUCTION

DEVELOPMENT OF SILICON ADSORBENTS

R&I activities for the development of two new adsorbents of silicon, present in the form of siloxanes in naphthas, were finalized. These silicon species that come from the decomposition of antifoaming agents are catalyst poisons that affect hydrotreatment and selective hydrogenation catalysts in particular. They are eliminated via chemisorption, a step that is optimized thanks to new mass surface reactivity concepts. These products are designed to be used in the refining sector, but also new fields: silicon is an impurity that has to be eliminated during the recycling of some plastics, for example.



CATALYSIS

FIRST TWO-STEP HYDROCRACKING CATALYST FOR NAPHTHA PRODUCTION

Researchers at IFFPEN have developed an innovative zeolite catalyst for the two-step high-pressure hydrocracking process targeting the selective conversion of heavy cuts into naphtha cuts, i.e., hydrocarbon bases suitable for introduction into a steam cracker to produce light olefins. It completes Axens' Craker® Flex range of hydrocracking catalysts addressing industry's need for flexibility towards the production of clean fuels or petrochemical bases.

GAS TREATMENT

A NEW SOLVENT FOR GAS SWEETENING

IFPEN's teams have developed a biogas sweetening process (decarbonization and desulfurization) that incorporates a new solvent resulting in improved performance and profitability. The process uses an innovative solvent that is more reactive and has a higher capacity than conventional amine solvents, while offering similar operability characteristics.

PETROCHEMICALS



A NEW 1-HEXENE PRODUCTION PROCESS

IFPEN has developed a new 1-hexene production process based on the trimerization of ethylene. This process makes it possible to obtain high-purity 1-hexene while consuming less energy. In the field of the production of petrochemical intermediates, this process, successfully marketed by Axens, addresses the significant growth in the demand for high-performance, polyethylene-type plastics.

CHARACTERIZATION AND MODELING OF CARBONATE RESERVOIRS

CARBONATE ROCK EXPERTISE SUPPORTING INDUSTRY THROUGH THE CARDIO™ AND AQUARIUS JIPS

IFPEN is consolidating its expertise in complex reservoirs and carbonate rocks through Joint Industry Projects (JIPs). These three-year collaborative projects make it possible for IFPEN teams to develop and validate methodologies and technologies in line with concrete industrial problems. For their part, industrial partners benefit from IFPEN's expertise and the results of its research. The CarDIO™ JIP was launched in 2019 to study the transformation of carbonate sediments into rocks as a result of early diagenetic processes, such as the action of surface waters with their specific chemical characteristics, within stratigraphic modeling. For its part, the Aquarius JIP is dedicated to carbonate-rich reservoirs in a heterogeneous lacustrine system, with the Green River Formation (USA) as a reference model. IFPEN organized a workshop on the theme, bringing together nine international companies.



FUNDAMENTAL RESEARCH SERVING INNOVATION

+ DIGITALIZATION

ANOTHER STEP FORWARDS IN THE FIELD OF DIGITAL TECHNOLOGY

Conscious that digital technologies are playing an increasing role in finding solutions to industrial problems, IFPEN is committed to intensifying its partnerships with experts in the field. The partnerships already in place have been very fruitful in 2020. For example, a five-year framework agreement with Inria in the field of high-performance scientific computation (HPC) reached a conclusion: the success of the research

conducted demonstrated the benefits of such an alliance. IFPEN and Inria decided to extend and strengthen their partnership, broadening its research scope to include artificial intelligence (AI) and high-performance data analysis to support the energy transition. With its partners, IFPEN also continued to develop new tools and new methods to support research organizations and industry. After the Plug im!™ platform dedicated to the processing and analysis of signals, images and 3D volumes, IFPEN, in partnership with Safran Tech, launched Lagun, an open-source data exploration and optimization web platform giving access to exploration, analysis, data exploitation and numerical simulation methods.

+ FOCUS

In order to raise the profile and increase the influence of its research, in 2017, IFPEN introduced a policy of open, free and unlimited access (open access) to its researchers' publications and associated data. In this context, IFPEN opted for a green open access approach, self-archiving articles on the HAL-IFPEN platform and supporting its researchers in their publication efforts. In 2020, 85% of articles published in peer-reviewed journals were archived in HAL-IFPEN. This initiative is in line with a French and European drive to encourage the sharing of research results and help accelerate innovation.

WORKSHOP

SCALE4MAT, A DIGITAL EVENT TO PROMOTE SCIENTIFIC DIALOG

IFPEN's first Scienc'Innov workshop on materials synthesis, Innovative materials: which scale-up methodology? (Scale4MAT), was held in webinar format on 24 and 25 November 2020. Its aim was to provide an opportunity for scientists to discuss a key priority for the future in the field of catalysis: new approaches to the modeling of unit operations, aimed at facilitating the extrapolation of syntheses of disruptive materials, from the laboratory scale. According to Marc-Olivier Coppens, Ramsay Memorial Professor, Head of the Chemical Engineering Department at University College London and IFPEN Scientific Board member, *"this type of event is particularly useful as it is an opportunity to tackle deep and fundamental problems within the framework of the research program, as well as applications and pilot projects, including on larger scales"*. This 100% digital format provided an ideal platform for exchange for the 110 participants - experts in the fields of heterogeneous catalysis and process engineering - from around the world, representing academia and industry. *"The ability to join an event from anywhere in the world facilitates and internationalizes dialog with external partners, and the fact that the events are recorded allows people to watch them back at their leisure. For scientists at IFPEN, it was also an opportunity to discover research conducted by their peers and to relate it to their own activities, for the cross-fertilization of disciplines and a fresh approach to challenges"*, he adds. He believes the ideal way forward would be to combine the spontaneity of face-to-face events with the effectiveness of digital formats, in order to support the energy transition in all its complexity.



GEOPOLITICS OF RENEWABLE ENERGIES

Interview with:

Emmanuel Hache, Economist-Prospective Specialist, Generate Project Manager

Between 2018 and 2020, in partnership with the French Institute of International and Strategic Affairs (Iris) and within the framework of the ANR Generate (Geopolitics of renewable energies and prospective analysis of the energy transition) project, IFPEN studied previously little explored economic, energy and environmental issues: the geopolitical consequences of a significant roll-out of renewable energies on an international level within the context of ambitious climate scenarios. Among these consequences, the criticality of metals (cobalt, copper, lithium, nickel and rare earths) used in low-carbon technologies was evaluated. We also mapped the intellectual property of renewable energies and the leading countries for these technologies, and measured the differentiated vulnerability of oil- and gas-producing countries. The fruit of improvements made to the TIAM IFPEN model by the team from IFPEN's Economics and Environmental Evaluation Department, these results, published in May 2020, are highly likely to guide decision-making with respect to the implementation of energy and climate policies around the world. Today, we are extending our energy and materials foresight research within the framework of IFPEN's new Climate, Environment and Circular Economy strategic priority.





ENCOURAGING AND SUPPORTING INNOVATION



INTERNAL INNOVATION

Interview with:
Bertrand Lecointe, project manager



The adventure began in 2018 during the first innovation challenge. The proposed solution – a removable powertrain to effortlessly transport any type of bed, stretcher or wheelchair and take the strain off hospital stretcher bearers, called OwlOne (see page 16) – was one of the winners. The technology was then developed within the IFPEN Transports Energie Carnot Institute. In parallel, various economic models to exploit the innovation were studied with the Incubation and SME department. The appropriate solution consisted in creating a structure. In 2020, industrial prototypes were developed and I decided to set up TechKare™ via the spin-off program. Through the latter initiative, IFPEN supports the entrepreneurial culture and provides its employees with the opportunity to take ownership of their aspirations. I am lucky that IFPEN has supported me through every step of my initiative. Together, we have honed, built and consolidated my project. Through the spin-off program, IFPEN has offered me a new career opportunity. The project is now coming to fruition: in 2021, I will leave IFPEN to take over at the helm of TechKare™.

EVENT

IFPEN PARTNER OF THE HELLO TOMORROW EVENT DEDICATED TO DEEP TECH

Each year, the Hello Tomorrow Global Summit brings together scientists, entrepreneurs and institutional players from the deep tech ecosystem. IFPEN partnered the 6th edition of the Hello Tomorrow challenge, sponsoring the Environment category. IFPEN awarded first prize to Celadyne Technologies, a young American company that has developed a nanocomposite membrane for fuel cells and electrolyzers, doubling their efficiency.

+ FOCUS

Watch the replay of the webinar on www.ifpenouvelles.com presenting IFPEN's support for start-ups and SMEs and testimonies from entrepreneurs.



+ PARTNERSHIPS

COLLABORATION WITH INVESTMENT FUNDS SUPPORTING INNOVATIVE YOUNG COMPANIES

Support for innovative start-ups also takes the form of financial participation in investment funds specializing in eco-industries and eco-energies, which invest in young companies and SMEs providing innovative services and technologies. In 2020, along with academic and industrial partners, IFPEN signed up to the Pertinence Invest 2 fund, dedicated to the funding of technological innovation resulting from work conducted by French universities and engineering schools. *"Pertinence Invest 2 was set up with the support of around twenty engineering schools and universities"*, explains Jean-Philippe Zoghbi, Managing Director of Sofimac Innovation. *The aim is to provide funding for the most promising deep tech start-ups, particularly those operating in the new energies sector. IFPEN's participation in the fund reflects its determination to support innovative companies through the upstream stages of their development.* IFPEN also continued to support funds managed by Demeter, the leading energy and ecological transition investor. *"IFPEN is one of Demeter's long-standing partners and contributes to several of our funds, be they in the field of innovation, with the D6 Smart City fund dedicated to the city and sustainable mobility, or more recently with the Agrinnovation fund dedicated to the production and use of agricultural biomass, or funds set up to support growth SMEs such as Paris Fonds Vert, dedicated to the energy and ecological transition in major metropolises. IFPEN's global expertise relating to the transition to low-carbon energy and its desire to share it lie behind the enduring nature of a partnership that goes from strength to strength each year"*, explains Éric Marty, Managing Partner at Demeter.



TRAINING TALENTED YOUNG PEOPLE FOR THE ENERGY TRANSITION

AWARDS

MORE AWARD-WINNING IFP SCHOOL STUDENTS

Once again, several teams of the School's students won awards in national and international competitions. Projects were selected for their quality and contribution to the ecological transition. Two teams won first and third prize in the Student Challenge organized by the French automotive engineers society (SIA). Two students on the "Electrification and Automotive Propulsion" Research Master's program won first prize with their project relating to the electrification of a 44-ton truck. Third prize was awarded to a team of students from the Powertrain Engineering program for an innovative solution incorporating hydrogen in the powertrain system. Another team from IFP School's class of 2020 won the Minus CO₂ Student Challenge, organized by the European Association of Geoscientists and Engineers (EAGE). They were recognized for their work analyzing subsurface oil field data and for the design of a plan to develop an economically viable carbon-neutral field.

WEBINARS

IFP SCHOOL VOICES: A NEW FORMAT FOR AN ALTERNATIVE APPROACH TO CURRENT ISSUES IN THE ENERGY AND POWERTRAIN SECTORS

In the fall of 2020, the School launched IFP School Voices, a series of webinars presented by alumni, IFP School teachers or IFPEN researchers. These short-format lectures tackle topical issues, primarily related to the ecological transition, and explore the latest trends and innovations in the energy and powertrain sectors. Aimed at the School's students and graduates, the first of these monthly sessions covered the impact of big data and AI in the exploration of sedimentary basins, the attainment of carbon neutrality and the evolution of the plastics sector.





THE DIGITAL CULTURE LABORATORY



Interview with:

Olivier Bernaert, associate professor in the Processes for Energy and Chemistry Center, LAB e.NOV™ manager

At the start of 2020, we launched an innovation and digital culture laboratory to encourage the promotion and support of initiatives in education and innovation. In creating LAB e.NOV™, our aim was to develop one of the differentiating aspects of our educational model. Concretely, it is a physical and virtual space dedicated to the experimentation of new technologies and training practices based on sharing and co-creation between teachers, researchers, students, IFP Group companies and IFP School partners. It comprises four units: an innovative education unit, a MOOC unit, an immersive realities unit and an entrepreneurship and design thinking unit.

The period we have just been through accelerated the development of innovative teaching approaches and educational materials. During the first lockdown in the spring of 2020, the teaching team exploited the combined expertise of the LAB e.NOV™ and the IT unit; this support, along with the digitalization of courses, ensured the continuity of teaching, projects and exams for all programs, from the very first day of lockdown. For example, some field placements were replaced with virtual reality experiences. In the fall, the new academic year began in hybrid mode, with some students present at the School and other studying remotely, to give students time - particularly those from outside France - to join us. ”

Watch the video about
LAB e.NOV™ on the Innovation
IFP School YouTube channel

CHAIR



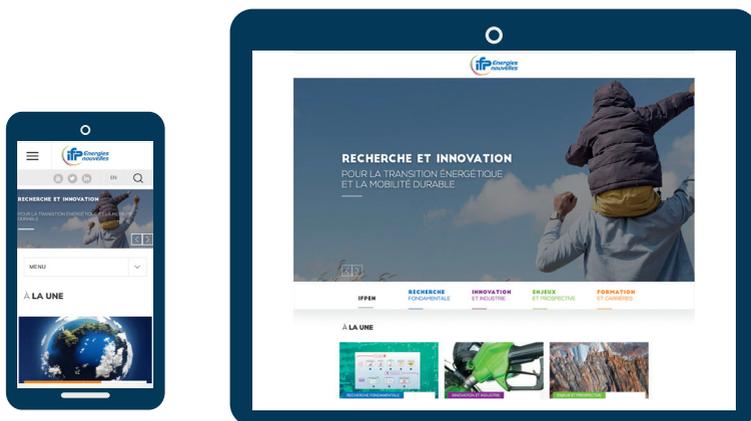
CARMA : A FINE DEBUT YEAR

The Carbon management and negative CO₂ emissions technologies towards a low carbon future” chair (CarMa), jointly held by Jean-Pierre Deflandre (IFP School) and Florence Delprat-Jannaud (IFPEN), was created in 2019 with the support of Total and in partnership with the Tuck Foundation. It is dedicated to negative carbon dioxide emissions and associated solutions. In 2020, the chair developed its activities with: the

recruitment of a PhD researcher and two post-doctoral researchers to work on the deployment of bioenergy with carbon capture and storage, the state of the art concerning negative greenhouse gas emissions and their environmental evaluation respectively; the incorporation of the theme in several IFP School programs; and lastly, the launch of a dedicated website, aimed at promoting and sharing the CarMa chair’s research and activities in the field of education, in order to contribute to public and scientific dialog surrounding carbon-related issues. Demonstrating the interest in the Chair, a partnership agreement has also just been signed with the CNRS.



Follow IFPEN news on
www.ifpenergiesnouvelles.com



[Access the 2020 full activity report of IFPEN](#)



Find IFPEN and IFP School on social media





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



• **Editors:** IFPEN • **Design & Layout:**  WAT • **Atelier Typao** • **Printing:** document printed on FSC mix credit-certified paper • **Photo credits:** Adobe stock AA+W, Alexander Raths, Boggy, Busara, Chokniti, Digitalstock, Dmitry Chulov, Foton1601, Fottoo, Insta_photos, JRJfin, Lev Dolgachov, LK Photography, Madamlead, Matyas Rehak, Ndad Creativity, OscarStock, R. Gino Santa Maria, Rawpixel.com, Ricardo Reitmeyer, Rost9, Sdecoret, SerPhoto, SmirkDingo, Teksomolika, Zinkevych ; Benedicte Govaert ; Clémentine Béjat ; Getty Images ; IFPEN Georgejmlittle, Prosernat, Sabine Serrad ; Objectif Images.

All rights reserved.



MEETING TOMORROW'S CHALLENGE TODAY

- + IFP Energies nouvelles is a major research and training player in the fields of energy, transport and the environment. From research to industry, technological innovation is central to all its activities.

+

WWW.IFPENERGIESNOUVELLES.COM

