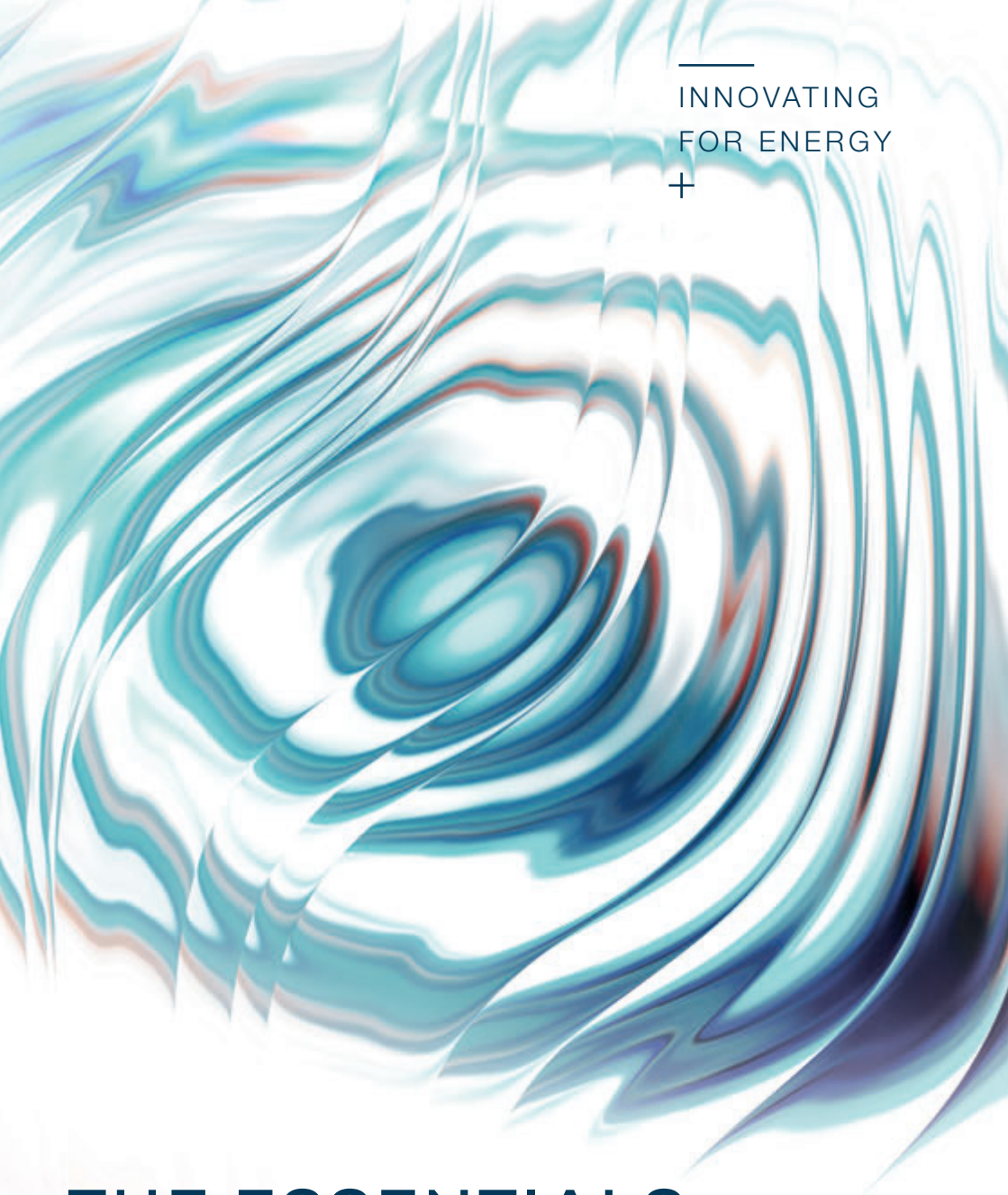


INNOVATING
FOR ENERGY

THE ESSENTIALS

2022

IFP Energies nouvelles

INTERVIEW WITH PIERRE-FRANCK CHEVET, CHAIRMAN AND CEO OF IFPEN

INNOVATING FOR A LOW-CARBON AND SUSTAINABLE WORLD

In June 2022, the results of our Horizon 2035 initiative, the fruit of a collective reflection process launched in 2021 aimed at drawing up a strategic vision, were presented to the board of directors. This vision sets out IFPEN's trajectory for 2035 in terms of its research programs and its organization.

I welcome the creation of our new committee of stakeholders. This committee reflects IFPEN's determination to improve how it takes society's expectations into account in its research programs as well as the way it conducts activities, the ultimate aim being to optimize its strategy.

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.

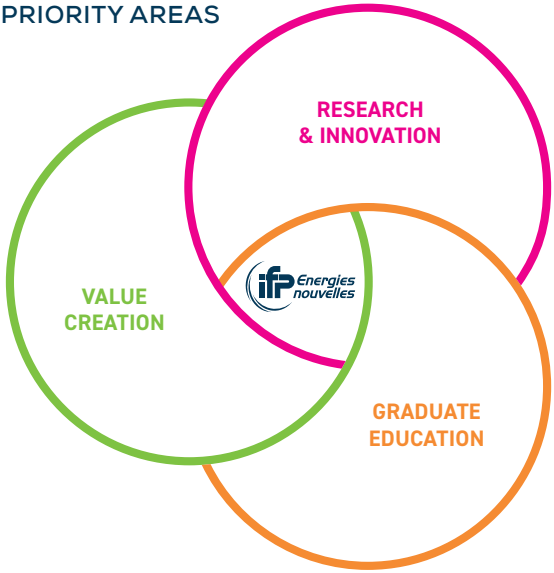
OUR MISSION

BACKGROUND
CLIMATE CHANGE
AND ECOLOGICAL TRANSITION

+ CHALLENGES

- **FOSTERING SUTAINABLE MOBILITY**
- **DIVERSIFYING THE ENERGY MIX**
- **INCREASING ENERGY EFFICIENCY**
- **REDUCING THE ENVIRONMENTAL IMPACT OF FOSSIL RESOURCES**

+ 3 PRIORITY AREAS



KEY FIGURES

1.549
total full-time equivalent workforce for 2022

including

1.078
researchers and R&I technicians

30
work/study students (FTE)

Nearly

170
PhD students, post-doctoral researchers and placement students (FTE)

€259.7 MILLION
for R&I Operating expenses

72%
of budget dedicated to NETs

2
Carnot Institutes: the IFPEN Transports Energie Carnot Institute and the IFPEN Ressources Energétiques Carnot Institute

Awarded
ISO 9001
certification for their R&I activities

138
basic patent applications, including
102
in the field of NETs

More than
500
IFP School graduates

DEVELOPING TODAY THE INNOVATIONS OF TOMORROW

CLIMATE, ENVIRONMENT AND THE CIRCULAR ECONOMY

Given the climate challenge and the impact of human activities on the environment and resource availability, IFPEN is reinforcing its actions via an ambitious strategy targeting three main objectives:
the decarbonisation of industry and CO_2 conversion, the recycling of plastics and metals from catalysts and batteries, and the improvement of air quality, soil resilience and the water cycle.

RENEWABLE ENERGIES

To address the demand for renewable energies, IFPEN develops processes to produce second-generation bioproducts and biofuels. IFPEN also designs tools targeting the development of ocean energies, particularly floating wind turbines. Lastly, to support the growth in non-dispatchable energies and the increasing electrification of the economy, IFPEN is working to improve energy storage and management technologies.

SUSTAINABLE 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 hydrogen, biogas or electricity and exploit the optimization potential provided by digitalization. To navigate this energy and ecological transition concerning the sector's players, local authorities and citizens, IFPEN is mobilized in France and Europe via its Carnot IFPEN Transports Energie (TE).

RESPONSIBLE OIL AND GAS

Given the need to increase energy efficiency and reduce CO_2 emissions and pollution generated by industry and transport, while meeting the global demand for mobility, energy and products for the chemicals sector, IFPEN conducts research aimed at producing fuels and chemical intermediates meeting the strictest standards. At the same time, it develops technologies making it possible to reduce the risks associated with the exploration and exploitation of oil and gas resources.

FUNDAMENTAL RESEARCH SERVING INNOVATION

To ensure the scientific excellence of its research activities and to support its innovation ambitions, IFPEN draws on a collaborative fundamental research program, organized around nine scientific challenges. Moreover, in order to anticipate long-term needs and pave the way for the development of new products and processes, IFPEN continually adjusts its scientific questions with a view to acquiring new knowledge and skills.

IFPEN 2022 NEWS IN BRIEF

CARBON NEUTRALITY OBJECTIVE BY 2050: THE INTERNATIONAL CIVIL AVIATION SECTOR ADOPTS THE RESOLUTION

The adoption of the resolution defining carbon neutrality by 2050 as a climate objective for the international civil aviation sector was approved in October 2022 at the 41st assembly of the ICAO. This resolution reflects the commitment – to the process aimed at decarbonizing the aviation sector – of States*, and aviation and energy sector players, including IFPEN, who co-signed the preparatory call via the Toulouse declaration in February 2022. The co-signatories, taking into account society's expectations in the field of the decarbonization of transport, particularly aviation, submitted proposals aimed at achieving carbon neutrality through the +improvement of aircraft technologies, the increased use of biofuels, carbon pricing, financial incentives and support for environmental and climate innovation.
To this end, Pierre-Franck Chevet gave a presentation underlining IFPEN's determination to contribute to the energy and ecological transition of the aviation sector by providing technological support for the production of advanced biofuels.

** The 27 States of the EU, 10 States of the European Civil Aviation Conference (Albania, Georgia, Iceland, Moldavia, Monaco, Norway, UK, San Marino, Serbia, Switzerland)*

IFPEN CO-ORGANIZES THE GHGT-16 CONFERENCE ON CO_2 CAPTURE, UTILIZATION AND STORAGE (CCUS)

With more than 20 years' R&I experience in the field of CCUS, IFPEN co-organised the 16th edition of the IEAGHG (International Energy Agency Greenhouse Gas R&D Program) conference on greenhouse gas control technologies, alongside the Club CO_2, ADEME, BRGM and TotalEnergies. At a time when decarbonization objectives call for an acceleration in CO_2 emission reductions, this event was the focal point for international research in CCUS technologies, bringing together more than 1,200 participants to discuss the solutions designed to help meet the objectives set out in the 2015 Paris Climate Agreement.

FOSTERING THE EMERGENCE OF INDUSTRIAL CHAMPIONS IN FRANCE: THE INFORMATION-GATHERING MISSION OF THE FRENCH SENATE CONSULTS IFPEN

In February 2022, Pierre-Franck Chevet and Nathalie Alazard-Toux, Director of the Industrial Development Business Unit, were formally consulted as part of the French Senate's information mission: "*Excellence de la recherche et de l'innovation, pénurie de champions industriels : cherchez l'erreur française*" (Research and innovation excellence, shortage of industrial champions: identifying where France has gone wrong), and underlined the importance of links between research and the industry in order to optimize the transfer of innovation. The mission's objective was to identify the obstacles encountered by France in order to reinforce its applied research and define ways of preserving and cultivating its innovation pool today, with a view to having major European champions tomorrow.

PATENTS, VECTORS OF INNOVATION FOR THE ECOLOGICAL TRANSITION

Thanks to its capacity for innovation and its industrial development policy IFPEN is well placed in national and international rankings of patent applicants. The growing proportion of patents filed by IFPEN in the NTE field reflects its commitment to the ecological transition. For example, the "Hydrogen patents for a clean energy future" study conducted jointly by the European Patent Office (EPO) and the International Energy Agency (IEA) and presenting the major trends in the field of hydrogen technologies for the period 2011-2020, placed IFPEN second in the global ranking of patent filers among public research organisations in the field of H_2 technologies.

FOCUS

BENOÎT NOETINGER AND HIS PARTNERS ARE AWARDED AN ERC SYNERGY GRANT TO STUDY KARST AQUIFERS

Benoît Noetinger is an IFPEN researcher with a PhD in Physics, specializing in transport in random porous media. Along with Bojan Mohar from the University of Ljubljana (Slovenia), Philippe Renard from the University of Neuchâtel (Switzerland) and Marco Dentz from IDAEA-CSIC (Spain), he secured a prestigious ERC Synergy grant for the KARST fundamental research project. The grant will enable this international, multidisciplinary research team to study the physical laws governing water flow and the transport of pollutants in underground cave systems (karst aquifers). To ensure most of humanity has access to water, understanding the mechanisms of karst formation and studying the impact of climate change on these aquifers is of ultimate importance.

CLIMATE, ENVIRONMENT AND THE CIRCULAR ECONOMY

SOIL

Interview with:
Hassan Boukcim, CEO of Valorhiz

It is within the framework of a France Relance project, aimed at maintaining and supporting the employment of active researchers and young graduates, that Valorhiz and IFPEN forged a partnership relating to the development of methods for analyzing sandy soils, characterized by their low carbon content. A better understanding of unstable organic matter in these soils, which have been the focus of few studies compared to carbon-rich soils despite their storage potential, would make it possible to use them as carbon sinks in order to address the challenges of food security and climate control. Recruited for a period of 15 months, an engineer specializing in soil organic matter, shared between IFPEN and Valorhiz, will use our database to assemble a panel of different representative samples in order to analyze them and formulate new descriptors.

PLASTIC POLLUTION IN SOIL

OPTIMIZING THE QUANTIFICATION OF MICROPLASTIC POLLUTION IN THE ENVIRONMENT

To address widespread pollution caused by plastics and microplastics, the French National Adaptation Plan for Climate Change (PNACC) made the reinforcement and resilience of ecosystems one of its objectives. It is in within this context that the IFPEN RE Carnot Institute decided to make the issue of plastic waste flows in the environment one of its strategic priorities. Accordingly, in 2022, discussions were held with the Centre for documentation,research and experimentation on accidental water pollution (CEDRE) with a view to develop a rapid experimental method for quantifying microplastics in natural environments.

CO_2 CAPTURE

Interview with:
Laurent Viellard,
3D project operations manager at IFPEN

Developed in IFPEN's laboratories over a period of more than ten years, the DMX™ CO_2 capture process reached an important milestone with the launch of the 3D industrial pilot, within the framework of the Horizon 2020 project conducted alongside Axens, ArcelorMittal and TotalEnergies, at ArcelorMittal's Dunkirk site. Our objective? To demonstrate an innovative process for capturing CO_2 from steel industry flue gases. Following the construction of the pilot unit in the workshop in the form of modules and its assembly, reception and installation test, the last step consisted of pouring the solvent – the innovation at the heart of the technology thanks to its efficiency, competitiveness and durability – into the unit's columns prior to its circulation, once the blast furnace gas to be decarbonized has been injected.

RECYCLING OF CRITICAL MATERIALS

COMPLYING WITH REGULATIONS AND ENSURING THE INDEPENDENCE OF THE EUROPEAN MARKET

In 2022, the proof of concept and economic viability for catalyst metals was demonstrated over the course of a few months, laying the foundations for an acid leaching and direct reincorporation process. These first highly promising results demonstrated the potential of hydrometallurgical solutions (with or without separation), with respect to the explosion in demand for critical metals, paving the way for further work on battery metal recycling.

CHEMICAL RECYCLING OF PLASTICS

REWIND® PET: THE INDUSTRIALIZATION OF THE CHEMICAL RECYCLING OF PET IS WELL UNDERWAY

Axens and Toray Films Europe are studying the construction of a first PET recycling unit based on the Rewind® PET process developed by IFPEN, Axens and Jeplan. The process involves the optimized glycolytic depolymerization of PET combined with specific purification steps aimed at eliminating all organic and inorganic compounds present in PET waste. The new unit will be integrated at the existing polymerization plant located at Saint-Maurice-de-Beynost (Ain, eastern France). The objective is to recycle 80,000 metric tons/year of complex PET plastic waste and produce up to 100% transparent recycled PET for films, fibers and bottles suitable for food contact.

THE ENVIRONMENTAL ANALYSIS OF TRANSPORT

SUPPORTING THE TRANSITION IN MOBILITY

2022 aimed at feeding into roadmaps for different mobility sectors. For example, as part of the SESAME project, co-financed by ADEME, the Carnot IFPEN TE evaluated the benefits of the onboard measurement of pollutants using IFPEN's REAL-e™ tool, with a view to improving the technical control of vehicles, via tests conducted on an existing fleet.
In addition, following a request by ADEME, the E4T 2040 study was conducted, involving a prospective analysis of the technologies to be prioritized in order to reduce the CO_2 emissions of the road transport sector by 2040. Working with la Fabrique de la logistique, the Carnot IFPEN TE also designed the "Verdir ma flotte" ("Green my fleet") tool, which helps logistics sector players seeking to decarbonize their fleets quantify the economic and ecological impact of alternative fuels and hybrid and electric technologies. Lastly, it conducted a large-scale study for Concawe* aimed at evaluating the environmental footprint of plug-in hybrid vehicles (PHEV) in real operating conditions.

RENEWABLE ENERGIES

WIND ENERGY

SCIENTIFIC DAY EVENT DEDICATED TO WIND ENERGY: A GROWTH SECTOR WITH THE WIND IN ITS SAILS

French wind-energy sector players gathered in October 2022 for the first edition of the “scientific wind day event”. Organized by France Energie Éolienne and the IFPEN RE Carnot Institute, the purpose of this conference was to review the latest research developments and to support the sector’s growth on the eve of the 12th national wind symposium, at a time when France is set to play an increasingly important role in the field. Academic and industrial players shared their expertise and forged new alliances. At the event, IFPEN presented its turbine wake modelling technology, GP5 Ancre’s contribution to the synthesis of R&I needs in the wind sector and its participation in IEA-Wind’s OC6 project via a study of the aerodynamics and detection of defects relating to a turbine rotor.

GEOTHERMAL ENERGY

THE IFPEN RE CARNOT INSTITUTE CONTRIBUTES TO TWO NEW GEOTHERMAL ENERGY PROJECTS

The HocLoop project, funded by Horizon Europe, was launched at the end of October 2022. Working alongside its partners VITO, Norce and the Universities of Florence, Bari, Darmstadt and Vaasa, the IFPEN RE Carnot Institute is evaluating a new closed-loop technology based on a vertical well extended by a deep horizontal section. The fluid circulates in the annular and then in the central tube separated by an insulator. The system as a whole forms a closed-circuit thermal exchanger exploiting underground heat. The IFPEN teams are studying all phenomena associated with the technology using its expertise and tools in the field of reservoir and well modelling and surface equipment. They will also be working on design optimization as a function of underground properties and thermal recharge potential. In addition, the Gliter project, financed by ANR in partnership with BRGM and Lithium de France, is assessing the potential for the co-production of geothermal energy and lithium in the Upper Rhine Plain. This project was also launched at the end of 2022.

ENERGY STORAGE AND MANAGEMENT SYSTEMS

Interview with:
Louis Londe,
Technical Director, Projects and Innovation at Geostock

Long-standing partners Geostock and IFPEN worked together closely on an Advanced Adiabatic Compressed Air Energy Storage (AA-CAES) solution, a key development for the ecological transition. Compressed in caverns when electricity is abundant, the air is then discharged to produce electricity via a turbine. This compensates for the intermittent nature of energy generated by wind turbines and solar panels. In order to make the solution more efficient, compression calories are stored in a thermal storage facility and injected into the turbine during electricity production. We have pooled our respective expertise: IFPEN has contributed its know-how in the field of heat compression and storage while Geostock has brought its expertise in the field of underground cavity storage.

DECARBONIZATION OF AVIATION

THE BIOTJET PROJECT TAKES OFF

The BioTJet project dedicated to the production of sustainable aviation fuels, was launched. This project is supported by ADEME within the framework of the sustainable aviation biofuels call for projects. It is led by Elyse Energy and conducted in partnership with Alliance Forêts Bois and Avril and backed by Axens, Bionext and IFP Investissements. The objective is to construct and commission, by 2027, the first French industrial unit for the production of advanced biokerosene from sustainable biomass, primarily made up of local forestry and wood waste. In line with the French road map for the roll-out of sustainable aviation fuels, the national low-carbon strategy and European Fit for 55 regulations, BioTJet will provide an immediate response to the challenges associated with the decarbonization of the aviation sector. The use of advanced biokerosene stemming from BioTJet may reduce greenhouse gas emissions by at least 85% compared with conventional kerosene (on the basis of a life-cycle analysis). An option for the injection of green hydrogen obtained via water electrolysis is also being studied. Based on equivalent quantities of biomass, adding hydrogen to the process could double fuel production.

BIO-SOURCED CHEMISTRY

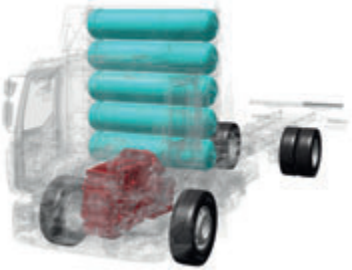
PLASTICS INDUSTRY ASSOCIATION: BIO-TCAT® ™, WINNER OF THE INNOVATION PRIZE

The Plastics industry association awarded the 2022 innovation prize in the field of bioplastics to American company Anellotech for its contribution to the development of the first 100% bio-based PET bottle thanks to Bio-TCat®™ technology, developed within the framework of a partnership between IFPEN, Axens and Anellotech for the conversion of lignocellulosic biomass into aromatics (Benzene/Toluene/ Xylenes). The TCat-8® pilot unit operated by partners in Silsbee (Texas) produced 100% bio-based p-Xylene in line with specifications for the first PET bottle prototypes, of 100% plant origin, manufactured at the end of 2021 by Suntory.

SUSTAINABLE MOBILITY

HYDROGEN-POWERED ENGINES

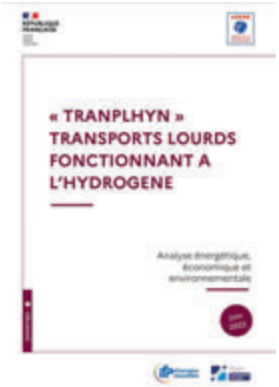
THE COST-EFFECTIVE DECARBONIZATION OF HEAVY MOBILITY



The PLH2 project, coordinated by Volvo Group – Renault Trucks in partnership with the Carnot IFPEN TE, is one of the projects being driven by the automobile and mobility research steering committee (Coram). It is aimed at equipping heavy-duty vehicles with hydrogen IC engines with a total cost of ownership similar to that of their diesel equivalent. The Carnot IFPEN TE is responsible for calibrating the MD 8 litre 6-cylinder engine. Existing technologies are currently being adapted with the aim of bringing costs under control. This engine could be used in either heavy trucks or buses. Volvo Penta is examining its potential use in shipping. The experimental base enables IFPEN's teams to verify the predictive capacity of 3D combustion calculations (cylinder pressure, combustion speed, wall heat transfer, etc.) and to examine the influence of control (injection phasing, lambda value, etc.) and geometric (hydrogen injector, spark plug, etc.) parameters on this combustion.

HYDROGEN-POWERED ENGINES

TRANPLHYN STUDY: EVALUATING THE BENEFITS OF HYDROGEN FOR HEAVY MOBILITY



In September 2022, with the support of ADEME, IFPEN published the TranpLHyn (heavy-duty hydrogen trucks) study. The study offers an energy, economic and environmental comparison of the two solutions for the use of hydrogen in a propulsion system: electricity generation in a fuel cell for electric drive and combustion in an IC engine with a conventional architecture. It concerned four types of vehicles and took into account four types of powertrain. The principal conclusions reveal that fuel cells perform better in terms of energy and the environment than hydrogen IC engines, but in both cases the total cost of ownership is between two and three times higher compared to a diesel engine, with an advantage for the hydrogen engine.

ELECTRIFIED MOBILITY

MELCHIOR PROJECT: FACILITATING MOTOR RECYCLING

In 2022, IFPEN and CEA-Liten Énergies du Futur launched the Melchior (*Machines électriques dans une chaîne de valeur orientée vers le recyclage* - Motors in a recycling-oriented value chain) project. This project aims to develop a prototype of a motor using magnet technology suitable for recycling. It will focus on specific materials and define architectures to facilitate recycling while maintaining a good level of performance. The Carnot IFPEN TE is responsible for designing this motor, including the evaluation of its environmental impact, while CEA-Liten will develop a new recyclable magnet technology.

DIGITALIZATION

Interview with:
Frederik de Smet,
research engineer at Ford

The main objective of the CEVOLVER project was to increase user confidence in electric vehicles by improving energy efficiency, reducing long-distance journey times and offering new functionalities. The project adopted a user-centric approach to optimize the exploitation of the thermal system. For the project, the Ford team provided a demonstration vehicle base on an E-Transit commercial vehicle and developed usage scenarios for Europe. The thermal equipment, including heating panels, a low-temperature radiator and a heat exchanger between two circuits, was optimized for these scenarios. In terms of software, CEVOLVER demonstrated that ecocharging, developed by IFPEN, minimizes long-distance journey times by optimizing charge maps. Eco-driving, IFPEN's other tool, reduces energy consumption for short distances.

RESPONSIBLE OIL AND GAS

CLEAN FUEL PRODUCTION

IFPEN develops eco-efficient catalysts and processes for the production of clean fuels, in line with product specifications as well as CO_2 emission reduction objectives, and supports the refining facility transition. In 2022, substantial progress was made with respect to the Prime-G+® gasoline desulfurization process, improving octane index in association with lower energy consumption. In addition, the development of a chlorine-free light naphtha isomerization catalyst was carried out, as well as the consolidation of R&I work targeting a new paraffin aromatization catalyst.

Prime-G+® is a major process for the purification of fuels and ensuring their compliance with the strictest specifications; one third of global gasoline production is obtained using this process. Within the framework of R&I work conducted at IFPEN and finalized in 2022, significant improvements were proposed to support the transition of refining facilities towards lower energy consumption and a reduced impact in terms of greenhouse gas emissions. Some sulphur-containing compounds such as mercaptans are particularly difficult to remove and make it more challenging to comply with environmental regulations in some areas of the world (particularly China). The improvement developed at IFPEN is aimed at adding an ultra-selective and total mercaptan adsorption step at the end of the process. This final purification means it is possible to make the upstream treatment steps “less stringent”, thereby reducing temperatures (and increasing energy efficiency), as well as hydrogen consumption by around 30%, guaranteeing a 10% reduction of the carbon footprint at the process terminals. These gains add up to a higher-quality product since the process improvement ensures compliance with all of the strictest environmental regulations worldwide. In addition, the higher octane gasoline produced is associated with increased engine efficiency, with a higher compression ratio and thus a reduction in CO_2 emissions when operating.

FUNDAMENTAL RESEARCH SERVING INNOVATION

FOCUS

In addition to the PEPR SNA's (French priority research programs and facilities initiatives associated with national acceleration strategies) in which it is a joint leader (PEPR on the decarbonization of industry with the CNRS, PEPR on bio-based products and sustainable fuels with INRAE and PEPR on the digitalization and decarbonization of mobility with Gustave Eiffel University), IFPEN is actively involved in the PEPR SNAs on Batteries and H2, as well as in the exploratory PEPRs on Underground common good (CNRS, BRGM), Maths-vives (mathematics for the living world, the environment and society – led by CNRS), FairCarboN (carbon cycle – led by CNRS and INRAE), OneWater (water common good – jointly led by BRGM, CNRS and INRAE), NumPEX (highperformance numerical methods for exascale computing – jointly led by CEA, CNRS and Inria) and Diadem (integrated mechanisms for the acceleration of the roll-out of emerging materials – jointly led by CEA and CNRS).

SUSTAINABLE ENERGIES

TWINN2SET: THE TWINNING OF RESEARCH LABORATORIES THROUGHOUT THE EUROPEAN UNION TO ACCELERATE RESEARCH ON SUSTAINABLE ENERGIES

In October 2022, the European Twinn2SET* (Twinning to sustainable energy transition) project was launched by IFPEN, IFP School, Stavanger University (Norway) and the Greek Geoenergy Institute (FORTH/IG), project leader, with a view to helping the institute increase its research and training capacities on sustainable energy themes: carbon capture and storage, deep geothermal energy and underground hydrogen storage. Two exploratory studies will also be conducted in the fields of hydrogen storage in geological formations and geothermal energy.

** Twinn2SET, submitted within the framework of the Twinning coordination and support initiative (twinning with research laboratories of various levels of maturity), received funding from the European Union's Horizon Europe program through grant agreement No.101079246.*

PHYSICAL CHEMISTRY

CARMEN JOINT RESEARCH LABORATORY: A VERY PRODUCTIVE YEAR

The CARMEN Joint Research Laboratory was launched in 2019 for a period of five years to study porous solids, focusing on three classes of materials: zeolites, aluminas and clays, all of great interest for the energy transition. Although the laboratory faced some early challenges associated with the Covid pandemic, its teams had made significant progress by the half-way point in its mission. This research was related, in particular, to numerous methodological developments and to the acquisition of new data that enhances our understanding of porous media, with an accent on their transport properties. The CARMEN Joint Research Laboratory also represents a spirit of scientific sharing and influence within a community. For example, the laboratory was the driving force behind the CARMEN.EVOLUTION workshop, held on 21-22 June 2022. The objective? To jointly define the scientific and social challenges involved in the development of new materials for energy, and to determine the strategies required to meet these challenges.

PARTNERSHIP

IFPEN TAKES PART IN THE SIG ON UNCERTAINTY QUANTIFICATION

In October 2022, Paris-Saclay University launched the scientific interest group (SIG) LARTISSTE (*Laboratoire de recherche en traitement des incertitudes par apprentissage statistique pour la sûreté, la conception et la transition énergétique*, or research laboratory on uncertainty treatment through statistical learning for safety, design and the energy transition). Devoted to the quantification of uncertainties in numerical simulations, this SIG brings together numerous researchers from academia, national research institutions and industry*. Uncertainty quantification concerns the modeling of physical, chemical, climatology and biological, phenomena, etc. Within this context, IFPEN will host two theses, one with CentraleSupélec on uncertainty quantification for wind energy and the other with ONERA on the optimization of multiphysical coupled systems.

** IFPEN, EDF, CEA, Framatome, CentraleSupélec, AgroParisTech, CNRS, INRAE, Inria, Paris-Saclay University, ENS Paris-Saclay, Évry University, Versailles Saint-Quentin-en-Yvelines University, ONERA, Safran, Airbus, Phimeca, Cerfacs, Clermont Augnergne INP and IRT SystemX.*

AWARD

Hélène Olivier-Bourbigou is awarded the Codron- Fautz prize

Hélène Olivier-Bourbigou, IFPEN's fundamental research coordinator, was presented with the first Codron-Fautz Award by the Institut de France. Created in 2021, this annual award recognizes a researcher who has carried out remarkable work in the field of science applied to technology, as proposed by the French Academy of Sciences. In this case, it recognizes firstly a scientific approach ensuring that there is a continuum between fundamental research in the field of homogeneous catalysis and industrial applications and, secondly, the results of research into the design and implementation of more efficient catalysts. These make for more sustainable and economically-competitive chemistry.

ENCOURAGING AND SUPPORTING INNOVATION

IFPEN contributes to the development of green industrial and sustainable mobility sectors, speeding up the detection of new energy technology opportunities. To achieve this, IFPEN is diversifying, both in terms of its industrial partnerships and the development of its subsidiaries, and supporting the competitiveness of SMEs and innovative startups, thereby contributing to job creation and local wealth. Underpinning this, IFPEN encourages the expression of a genuine in-house innovation culture.

SUPPORTING ITS EMPLOYEES TO REINVENT ITSELF

IFPEN is diversifying in the field of new energy technologies, firstly by encouraging the creativity and entrepreneurial spirit of its own employees In 2022, the company continued to support the development of winning projects from the latest internal challenge. These projects deal with the phenomenon of clay shrinkage or swelling, which causes significant damage to buildings, make it possible to produce a chitin polymer for agrifood or medical applications via the use of enzymes, or provide a solution to filter microplastic fibers discharged by washing-machines, for example. All these projects are the result of an innovation culture enabling IFPEN to reinvent itself in order to address the challenges of the ecological transition. Via its spin-off policy, IFPEN also helps employees seeking to set up their own companies. In 2022, with the support of IFPEN, an employee set up So Sponge, a company proposing an energy-free humidity control solution for agricultural greenhouses.

SUPPORT FOR INNOVATIVE START-UPS AND SMES: THE NETWORK EXPANDS

IFPEN has been actively supporting SMEs and startups spearheading innovation projects for more than 35 years. These projects are in line with the triple ecological, energy and digital transition. To identify collaborative opportunities, IFPEN can draw on an extensive network of partners: target incubators, innovation support networks and the Carnot Institute network. Support for innovation also takes the form of financial participation in investment funds specializing in eco-industries, eco-energies and sustainable mobility, which invest in young start-up companies. In 2022, IFPEN contributed to FAIM, a seed and venture capital environmental and social impact fund sponsored by the cities of Lyon and Saint-Etienne. Also this year, YLEC Consultants turned to IFPEN for help to obtain International Maritime Organization (IMO) certification for its ship hold oil/ water separator.

Interview with:
Olivier Pernot,CEO of Soclema

Soclema contacted IFPEN through the Axelera competitiveness cluster to develop a previously non-existent solution, in line with its focus on renewable gases: ultra-low flow gas odorization. As well as the technical resources to validate the technology, IFPEN contributed its knowledge of fluids, meeting the specifications via test bench trials in line with demand. The deliverable was particularly useful for us to demonstrate the feasibility of the solution to our gas partners. IFPEN also made sure the semi-industrial system was perfectly operational and provided support for the patent filing process. GRTgaz, GRDF and Teréga accepted the prototype: the trials conducted in real conditions in their laboratories, and then out in the field, were conclusive and resulted in the solution being taken to market.

FROM RESEARCH TO INDUSTRY: IFPEN SUPPORTS THE RISK ASSOCIATED WITH INNOVATIVE COMPANIES

IFPEN, a new technology initiator, takes these innovations through to the industrial stage by seeking industrial and financial partners and project leaders. For example, 2022 saw the culmination of a collective adventure that started more than ten years ago: the industrialization of the BioTfueL® process. IFPEN, Avril and BioNext joined forces with Elyse Energy to create the BioTJet® project company, which will operate France's first industrial unit dedicated to the production of advanced biokerosene from sustainable biomass (see page 14). IFP Investissements and Axens acquired stakes in the company alongside Elyse Energy, Avril and BioNext to support the study and construction of this new plant.

Interview with:
Michel Thomas and Hélène Biguerd, IFPEN engineers

IFPEN helped Agua de Sol develop a new type of solar panel dedicated to drinking water production: fixed via adsorption overnight, atmospheric water vapour is desorbed during the day, then condensed and recovered for consumption. Solar radiation provides the energy (heat and electricity) for sterilization purposes. We joined the project in 2021 to help the SME optimize the choice of solid used as an adsorbent. We selected several aluminaand zeolite-type solids and tested them for their water adsorption capacities and characteristic desorption temperatures in order to compare them with the silicabased solution used by Agua de Sol during the development phase of the technology. The adsorbent recommended as an alternative to silica gel, at the end of the series of trials, will be tested in real conditions in the solar panel by the partner.

TRAINING TALENTED YOUNG PEOPLE FOR THE ENERGY TRANSITION

IFP School, an applied graduate school and apprentice training center (CFA), prepares its students to be active players in the energy transition. The school has a dual objective: to address industry's needs and society's aspirations by providing outstanding training programs in the fields of energy and sustainable mobility, based on innovative teaching methods. It is also supported by an ecosystem of academic and industrial partners in France and around the world, research activities and a committed socially responsible approach.

GRADUATE PROGRAMS ADAPTED TO INDUSTRIAL AND SOCIETAL NEEDS

IFP School prepares new generations of talented young people to drive development in the energy and mobility sector in order to build a low-carbon world. Consequently, the ten specialized engineering degree programs are continuously adapted and the share of teaching hours dedicated to new energy technologies is constantly increasing.
In 2022, recognition of the quality of course programs and their relevance to companies' needs was reflected in the renewal of the Specialized Master's® label for the Powertrain program and the signing of a partnership agreement with Strasbourg University for the imminent launch of a master's program in the field of georesources.

FOCUS

IFP School, which aims to be exemplary when it comes to incorporating current societal, economic and environmental concerns, is fourth in the HappyIndex®AtSchool rankings of engineering schools in terms of their commitment to the challenges of social responsibility (CSR category).

AN EDUCATIONAL APPROACH THAT IS CONSTANTLY BEING REINVENTED

IFP School proposes course programs based on innovative and agile teaching methods that prioritize experimentation for better knowledge acquisition. Real cases, serious games, virtual reality, the use of industrial software, etc.: innovative training methods can also provide an alternative to overcome issues relating to safety and access authorization to components and facilities.
While students take part in numerous field placements, digital tools and digitalization of course programs make it possible for students to go further in the discovery of professional environments or their learning of professional practices. The School draws on developments emerging from LAB e·NOV™, its digital culture laboratory. In 2022, the team supported the development of a module on hydrogen and mobility and designed a MOOC in the form of an online series on the energy transition. Permanently at the cutting edge of innovative education, LAB e·NOV™ acquired a 3D printing studio.

A SUCCESSFUL DEVELOPMENT STRATEGY

In 2022, off-site operations led by IFP School in partnership with IFP Training continued apace and several programs were renewed: The 20th edition of the Petroleum engineering and project development master's in Nigeria; the third intake of the Petroleum Upstream Techniques & Economics and Petroleum Downstream Techniques & Economics master's programs in Côte d'Ivoire; the second session of the specialized master's in oil and gas engineering in Senegal.
In addition, the School's development strategy led to the forging of new partnerships with companies positioned in the energy transition markets. Research activities conducted at IFP School also contribute to its influence via the publication of scientific articles and conference papers. These relate to research conducted within the School's four teaching chairs: Electricity and Digital Transition (EDT); Electric, Connected and Autonomous Vehicles for Smart Mobility (ECAV); Electrolyte Thermodynamics (EleTher) and Carbon Management and Negative CO_2 Emissions Technologies Towards a Low-Carbon Future (CarMa).

CSR

Interview with:
Sidney Lambert-Lalitte,
manager of the Energy technology economics and management program and coordinator of the Initiatives for a sustainable campus club

Of course, when it comes to its CSR approach, the School is supported by the expertise of an officer responsible for its implementation in line with IFPEN's policy. It also draws on initiatives driven by IFP School personnel and by its students, who belong to a generation concerned by sustainable development issues on a daily basis. Through the Initiatives for a sustainable campus group, which was created in 2018 and which I coordinate, we're working together to implement concrete actions aimed at making sustainable development a reality on campus. Successful initiatives include: an awareness-raising campaign concerning eco-practices, the publication of a sustainable development guide proposing local solutions that can be applied on an everyday basis, the distribution of re-usable water bottles to reduce plastic use on the School site. I support students in their initiatives as well as for organizational and budgetary aspects. And longer term initiatives are not overlooked! They are presented to the School management for their potential permanent implementation. I'm thinking here, for example, about proposals concerning the reduction of the transport carbon footprint of lecturers as well as students travelling to their placement sites.

ONLINE TRAINING

DELVING INTO THE HEART OF THE ENERGY TRANSITION AND INNOVATIONS FOR A LOW-CARBON FUTURE

At the start of 2022, IFP School launched two online training modules designed with the support of LAB e·NOV™ by teaching staff in collaboration with IFPEN researchers. The first, Energy Transition, derived from the Energy transition for a low-carbon future MOOC, contained a selection of video clips and games. The second module, Hydrogen for Mobility, gave students the chance to discover hydrogen technologies applied to heavy mobility through three sequences of video clips: H_2 production methods, hydrogen IC engines and fuel cell vehicles. These modules, which brought together more than 5.000 participants, were followed by webinars giving those taking part the opportunity to go into the concepts in greater depth and interact with designated teams.

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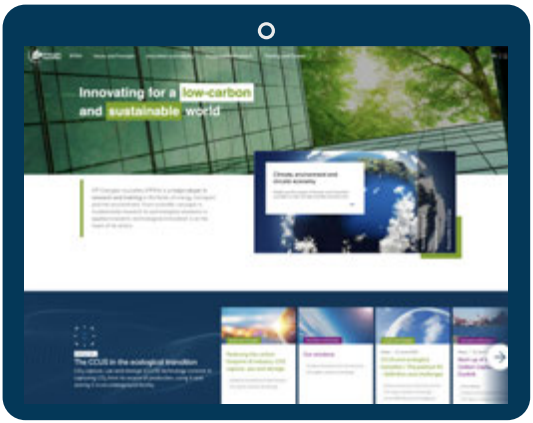

Access the 2022 full activity report of IFPEN

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MEETING TOMORROW'S CHALLENGE TODAY

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 directions: climate, environment and circular economy – renewable energies – sustainable mobility – responsible oil and gas.

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