

2017
IFP Energies nouvelles,
fundamental research
serving innovation



IFP Energies nouvelles (IFPEN) is a French public research and training player. It has an international scope, covering the fields of energy, transport and the environment. From research to industry, technological innovation is central to all its activities.

As part of the public interest mission with which it has been tasked by the public authorities, IFPEN focuses on:

- providing solutions to take up the challenges facing society in terms of energy and the climate, promoting the transition towards sustainable mobility and the emergence of a more diversified energy mix;
- creating wealth and jobs by supporting the competitiveness of related industrial sectors.

IFPEN's programs are hinged around three strategic priorities:

- **Sustainable Mobility:** develop effective, environmentally-friendly solutions for the transport sector
- **New Energies:** produce fuels, chemical intermediates and energy from renewable sources
- **Responsible Oil and Gas:** propose technologies that meet the demand for energy and chemical products while improving energy efficiency and reducing the environmental impact

An integral part of IFPEN, its graduate engineering school – IFP School – prepares new generations to take up the challenges of the energy transition.

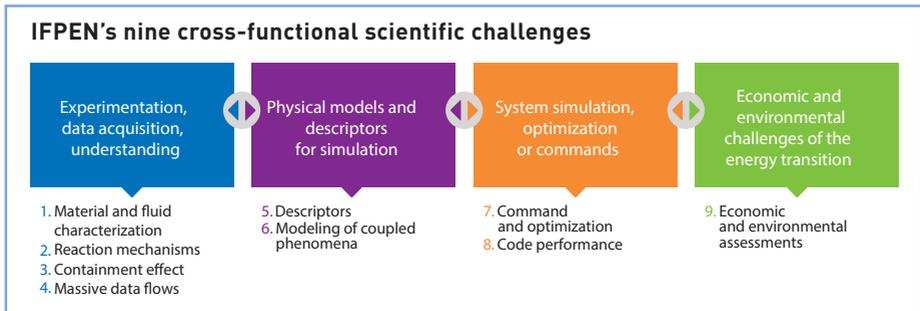


An ambitious fundamental research...

IFPEN fundamental research is designed to promote and accelerate the emergence of technological innovations.

Structured

The challenges associated with the energy transition give rise to a broad range of **open scientific questions**. To address these questions in a **coherent and transparent** manner, IFPEN's fundamental research activities have been structured around **nine scientific challenges**. By focusing the research effort, this organization is designed to accelerate the acquisition of the knowledge and to feed the innovation process.



Dynamic

While IFPEN's fundamental research is organized around nine broad challenges, it is annually implemented on the basis of a set of **"specific scientific issues"**. Today, it is focusing on around fifty of these.

A specific scientific issue identifies a scientific hurdle that is hampering the development of IFPEN's innovations and needs to be overcome. Each specific scientific issue is associated with a research strategy, in the form of a multiannual **action plan** that is **reviewed every year** according to results and new difficulties identified.

Steered

Action plans integrated into road maps lead to the operational implementation of **research projects**. These concern either cross-disciplinary issues of interest to several IFPEN's activities or the development of knowledge required for targeted applications. The specific scientific issues are efficient tools for steering IFPEN's fundamental research programs. By making its research more transparent, they also facilitate IFPEN's **synergies with other research communities**.

■ Fundamental research represents around **30%** of IFPEN's R&D activities

... implemented and adapted in various forms

Working with leading partners

In order to develop the solutions and industrial sectors of the energy transition, IFPEN has been involved in the **French Research and Innovation System** (SFRI) since its creation by the public authorities and participates in numerous collaborative projects. IFPEN also brings its expertise and skills to major projects on a **European level (ERA)**.

- ANR*-funded projects: over **20 participations** to ongoing projects in 2016 (with about one third of which as a project leader)
- More than **300** collaborations with French and international academic partners
- H2020-funded projects: in 2016, IFPEN participated in **12** proposals, **4** of which as coordinator, with a success rate of 50%
- **7** visiting scientists hosted since the beginning of 2016

* French National Research Agency

Constant rejuvenation thanks to young researchers

Research-based training at IFPEN offers students and young researchers the chance to join one of its R&D divisions and work for a fixed period within a **stimulating research environment, with access to first-class laboratory infrastructures and computing facilities**.

■ Internship program

Opportunities for French and international students: internships typically run for a 4 to 6-month period.

■ Doctoral studies program (PhD)

More than 40 new doctoral research projects started every year in cooperation with French and international universities: all PhD students are part of IFPEN's Doctoral College and have access to dedicated seminars and training sessions.

■ Postdoc program

Postdoc positions are available for PhD holders who have obtained their degree not more than three years ago.

- *To apply for these opportunities:* training@ifpen.fr
- *More information at:* www.ifpennergiesnouvelles.com/Training/Training-mission



Networking and outreach

IFPEN also maintains its high level of excellence by promoting exchanges between its researchers and the scientific community via **international scientific events**, relating to emerging or recurrent topics, designed to:

- offer a dynamic and attractive forum for research teams,
- forge contacts for future collaborations.

In 2017, scientific events organized by IFPEN included:

- **Comchemistry – Computational chemistry for pollutant mitigation** (IFPEN Scientific event),
- **DEPOS 27 – Déformation des polymères solides:** Annual French polymers community conference,
- **JCAT 48 – Journées de calorimétrie et d'analyse:** Thermal analysis and calorimetry techniques applied to the characterization of materials and fluids for energy: annual conference of the *Association française de calorimétrie* (AFCAT - French Calorimetry Society),
- **C2E – Colloids and Complex fluids for Energies:** Systems understanding: from preparation to process design (IFPEN Scientific event in partnership with the CEA),
- **VISU 2017:** Annual conference of the CNRS “Geometric and Graphic IT, Virtual Reality and Visualization” research group,
- **From signal to information:** Scientific and trade conference of the *Société des experts chimistes de France* (SECF - French Society of Chemical Experts).



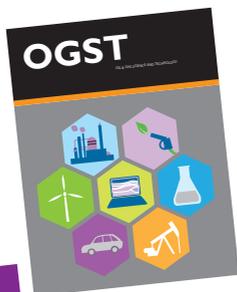
Events planned for 2018 include:

- **DataScien'2018: Learning from Scientific Data in Energy** (in collaboration with INRIA),
- **SLIMAIA – Solid Liquid Interfaces: Challenging Molecular Aspects for Industrial Applications,**
- **Energy Markets 2018: Commodities and Energy Market Organization in the Energy Transition Context,**
- **Trace Pollutants: Recent Advances in Chemistry, Analytical and Process Sciences – Industrial and Environmental Issues of Hg, As, Si, Cl.**

The dissemination of its scientific research is another way for IFPEN to make its R&D results accessible to all and to allow the scientific community to harness them.

- **Publications** in scientific peer-reviewed journals: around 200 per year.
- **OGST:** a bi-monthly journal for which IFPEN leads the editorial committee, concerning all disciplines and fields relevant to energy production, conversion, storage and use.
- **Science@ifpen:** a quarterly newsletter presenting scientific and technical results obtained by IFPEN's research teams through internal and collaborative activities.
- **Info Science news feed:** short news items, specially published on the IFPEN website and relayed on Twitter.

> Follow us:  @IFPENinnovation



Cutting-edge scientific skills and resources

IFPEN's employees form a unique body of **recognized scientific specialists from around the world** and an unparalleled network of expertise in a **broad variety of fields**.

Earth sciences

- Geology - Sedimentology
- Geochemistry
- Geostatistics - Geological modeling



Chemical sciences

- Catalysis and reaction kinetics
- Organic and mineral synthesis
- Separation techniques and adsorption
- Theoretical chemistry
- Analytical chemistry

Physical Sciences

- Chemical Physics
- Rheology
- Thermodynamics
- Petrophysics



Physical chemistry

- Complex fluids, colloids and condensed matter
- Surface, interface and materials science
- Electrochemistry and corrosion



Biosciences and biotechnology

- Microbiology
- Genomics
- Biocatalysis
- Fermentation

Engineering sciences

- Applied mechanics (solids and fluids)
- Chemical and process engineering
- Combustion and engine technologies
- Electrical and electronic engineering
- Automation and control systems
- Systems modeling and simulation



Mathematics and Computer sciences

- Numerical methods and optimization
- Signal processing
- Meshing and visualization
- Software design
- Real-time systems
- High performance computing



Economics

- Macro-economics
- Micro-economics and econometrics
- Technical-economic evaluation
- Environmental and life-cycle assessment

- 1,150 researchers
- 11,000 active patents
- 10 research divisions

Renewal of the IFPEN-SOLEIL framework agreement

The research framework agreement between IFPEN and the SOLEIL synchrotron was renewed for a period of four years in November 2016. This agreement gives IFPEN access to high-performance facilities and cutting-edge techniques for the detailed characterization of materials in the fields of **catalysis, geoscience and biochemistry**. Synchrotron radiation is notably used to **describe the porous texture of catalysts and low permeability rocks-reservoirs**. Since 2012, IFPEN has also been a partner in the Nanoimages X “Equipex” (Equipment for Excellence), a high-resolution 3D imaging facility coordinated by SOLEIL. The long-standing collaboration between IFPEN and the synchrotron reflects IFPEN’s firmly established roots in the Île de France region, particularly at the Saclay platform.



The 2017 IFPEN thesis prize is awarded to a graduated PhD student in Process Design and Modeling

This prize for the best IFPEN thesis defended in 2017 has been awarded to Zlatko Solomenko for his work on “Study of dual-phase flows and wetting in structured packings”. This thesis, conducted and supervised at IFPEN, was directed by the École centrale de Lyon. His original approach led to the development of a **model** taking into account **phenomena present on a nanometric scale**, as well as **methods for measurement on a liquid film scale**. This research helped overcome scientific challenge concerning “modeling of coupled phenomena”, thereby representing an advance for the design of new packing geometries. The objective is to improve the performance of gas/liquid contactors in equipment employed in **gas purification** or the treatment of combustion flue gases (**CO₂ capture** processes).



Horizon 2020: a high success rate!

In response to the various calls for proposals issued by the European Horizon 2020 program, IFPEN participated in the submission of 27 applications between 2016 and 2017. Of those that had been evaluated by the end of 2017, 9 projects were accepted. This satisfactory result is testament to the innovative nature of IFPEN's proposals and the **excellent fit between its strategic directions and European research priorities**. The projects accepted concern **sustainable mobility** (vehicles and fuels) and **low-carbon energy** (CO₂ management, renewable energies).



IFPEN PhD students awarded

- **Giovanni De Nunzio**, Grenoble Alps Community of Universities and Institutions 2016 **thesis prize**: "Eco-management of traffic in urban networks".
- **Bruno Miguel Da Silva Pinho**, International Society for Advancement of Supercritical Fluids **thesis prize**: "C3 hydrogenation in supercritical medium".
- **Zoé Buniazet**, **Young Scientist Award** at the 16th International Congress on Catalysis: "Investigation of water effects on heterogeneous acid catalysts: application to bio-alcohols dehydration into olefins".
- **Florian Perrotton**, **Second best student research article prize** from the *Association des économistes de l'énergie* (French Energy Economists Association): "The economics of rate-of-return regulation in the natural gas pipeline industry".
- **Saifuddin Ahmed**, **Helmut Knapp prize (poster)** at ESAT 2017 (European Symposium on Applied Thermodynamics): "Study of the influence of electrolytes on liquid-liquid balances using an equation of state".

Reinforced research/training cooperation with the Auvergne-Rhône-Alpes region

In 2017, IFPEN and the **École normale supérieure de Lyon** signed a framework scientific collaboration agreement, perpetuating a partnership that has lasted over 20 years. The objective is to **increase the efficiency of scientific research**, in particular by reinforcing research, knowledge transfer and innovation capacities. Excellence, cross-functionality and openness to industrial challenges are the keys underpinning this collaboration, which makes it possible to share scientific issues, identify emerging themes, harness skills and hence **ensure the coherence of fundamental research actions**, particularly in the field of modeling applied to catalysis, in order to effectively **address the main challenges of tomorrow's chemistry** and the energy transition.



The prestigious EFCATS PhD Award 2017 given to a former IFPEN PhD researcher

Kim Larmier is the **first French winner of the EFCATS PhD Award**, handed over to him in August 2017 for his thesis on “Isopropanol conversions on alumina solids: a mixed experimental/multiscale modeling approach”. His research led to the development of a methodology combining experiments, kinetic modeling and molecular modeling, in order to build predictive models for the performance of alumina catalysts employed for the dehydration of a bio-based alcohol. This step is especially important for the **conversion of lignocellulosic biomass into substances for the chemicals industry**. The EFCATS PhD Award is allotted every two years by the European Federation of Catalysis Societies and is the **most prestigious international thesis award in the field of catalysis**. Kim Larmier was also the winner of the IFPEN thesis prize in 2016.



From research tool to commercial software

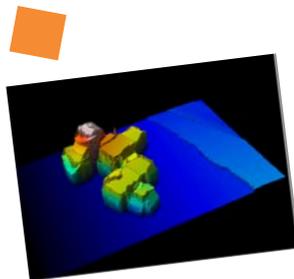
The HOT tool (Hybrid Optimization Tool), designed and developed by IFPEN for its researchers working in the field of vehicle hybridization, has been incorporated by Siemens PLM Software into its LMS Amesim IFP-Drive library. The optimization algorithms contained in HOT calculate the **best energy management for a given engine architecture**, on the basis of a given profile or driving cycle. Initially used in the context of research projects, today they are available to manufacturers who are now capable of selecting and **optimizing a complete hybrid structure** (IC engine, electric motor, battery, transmission, etc.). This evolution reflects IFPEN's capacity to **build its own development tools and enable industrial players to benefit from them** when they express a need to do so.

More than 1,500 OGST article quotations in 2016!

IFPEN leads the editorial committee of the **peer-reviewed journal** Oil & Gas Science and Technology (OGST). Indexed in the major international databases, OGST, now in all-digital format and available as an open access journal, covers all the disciplines and fields of activity within the scope of IFPEN. In 2016 and 2017, authors covered an extremely broad variety of themes, including numerical simulation for powertrains, modeling of low-permeability media, the impact of high-performance computing on the numerical simulation of fluid flows in industrial environments, or physico-chemical/mechanical pairing of fluids for modeling reactive interfaces. The OGST journal notched up 1,555 article quotations in 2016, giving it a two-year impact factor of 1.184, up from 2015 (1.087). OGST **articles and special reports are freely available at** <http://ogst.ifpenergiesnouvelles.fr>.

New stereo 3D reconstruction approach

In partnership with PSL-MINES ParisTech, IFPEN has co-developed a new stereo reconstruction approach from images obtained by electron microscopy. A method developed and validated for catalysts, which has also proved effective beyond this initial context: it was also **transposed to satellite images** as part of a competition organized by the American Intelligence Advanced Research Projects Activity agency. In addition, it has been shown to be effective for photographing everyday scenes. This opens up avenues of potential interest in other fields of application, including, for example, to **determine the relief of urban zones or supply three-dimensional information to industrial robots or driverless vehicles.**



A network of expertise nurtured by scientific visitors

As part of its scientific policy, in 2016 and 2017, IFPEN played host to foreign researchers from various domains:

- **Mikhail Varfolomeev**, an Associate Professor in the Department of Physical Chemistry at Kazan Federal University (Russia), worked on thermodynamic modeling tools for bio-based multifunctional molecules,
- **Ardalan Vahidi**, an Associate Professor at Clemson University (USA), worked on the contribution of driverless systems to vehicle energy efficiency,
- Professor **Sveva Corrado**, from the University of Roma Tre (Italy), worked on the thermicity of sedimentary basins,
- **Boutheïna Kerkeni**, a Professor in the Faculty of Sciences at Tunis University, worked on understanding the catalytic systems and reactions involved in the reduction of nitrogen oxides by SCR (Selective Catalytic Reduction) using ammonia,
- Professor **Per-Olof Gutman** from Technion (Israel Institute of Technology) worked on topics related to vehicle traffic regulation, and the control of systems used for marine renewable energies,
- **Edward Brightman**, a senior research scientist at the National Physical Laboratory in London. His research focused on the electrochemical conversion of CO₂,
- **Béatrice Rivière**, Professor and Head of the Computational and Applied Mathematics Department at Rice University (Houston, Texas), worked on the comparison of discontinuous Galerkin numerical methods in porous media – as applied by her research group – with other methods developed by IFPEN (hybrid grids) on basin and reservoir simulation cases, in the field of geosciences.



Innovating for energy

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