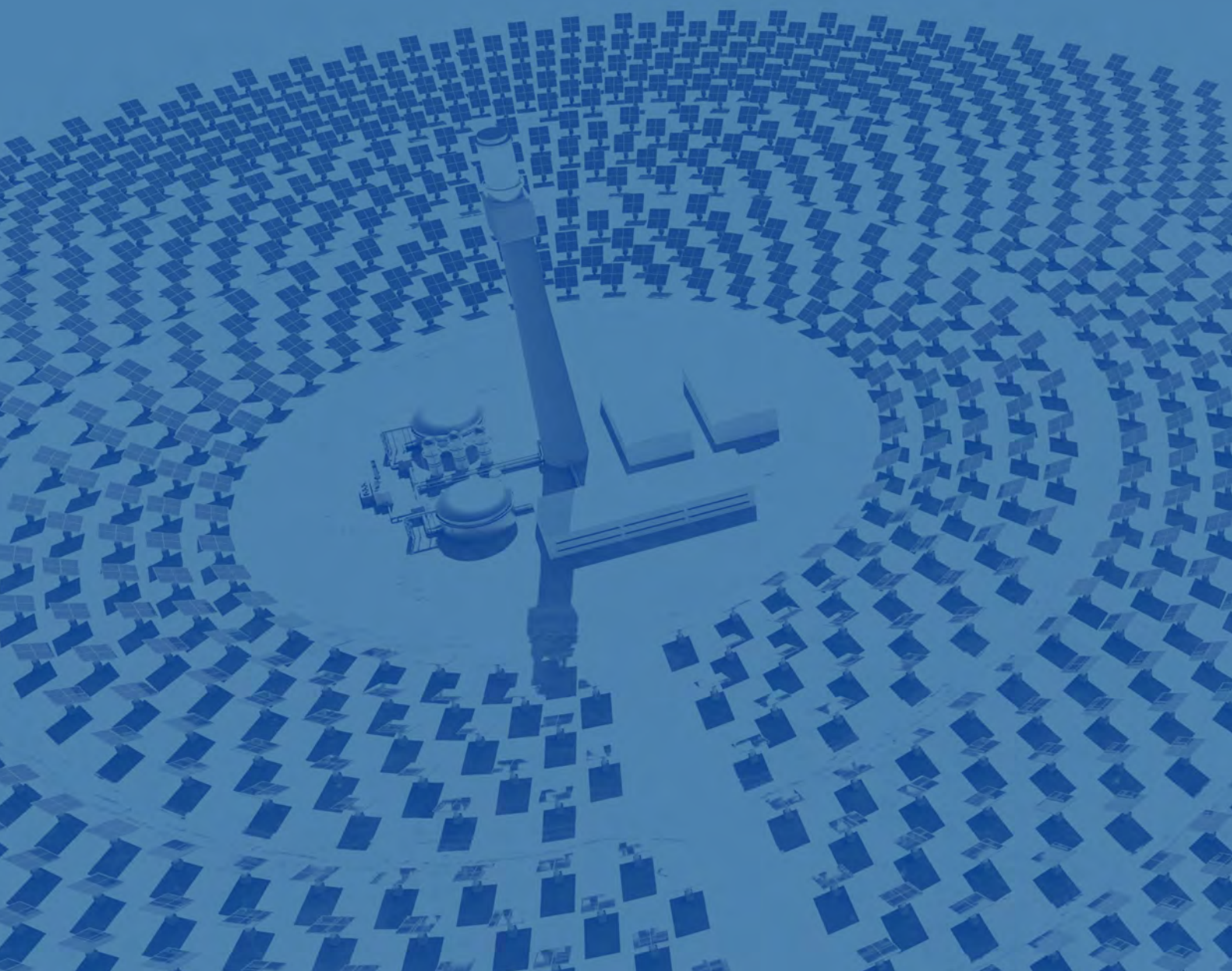
Paris-Saclay
A key player in the energy transition process



Paris-Saclay, a region at the service of sustainable innovation

The Paris-Saclay science and technology cluster represents 15% of all research in France and supplies 40% of public and private research jobs in the Paris Region. It's one of the eight most powerful innovation clusters in the world, along with the Silicon Valley, Boston, Tech City London, Beijing, Bangalore, Skolkovo Innovation City in Russia, and the Israeli Silicon Wadi.

Located on the outskirts of the French capital, Paris Saclay is a hotbed of innovation with a world-class reputation, boasting an unrivaled concentration of higher education institutions, state research laboratories, private R&D facilities and innovative businesses of all sizes.

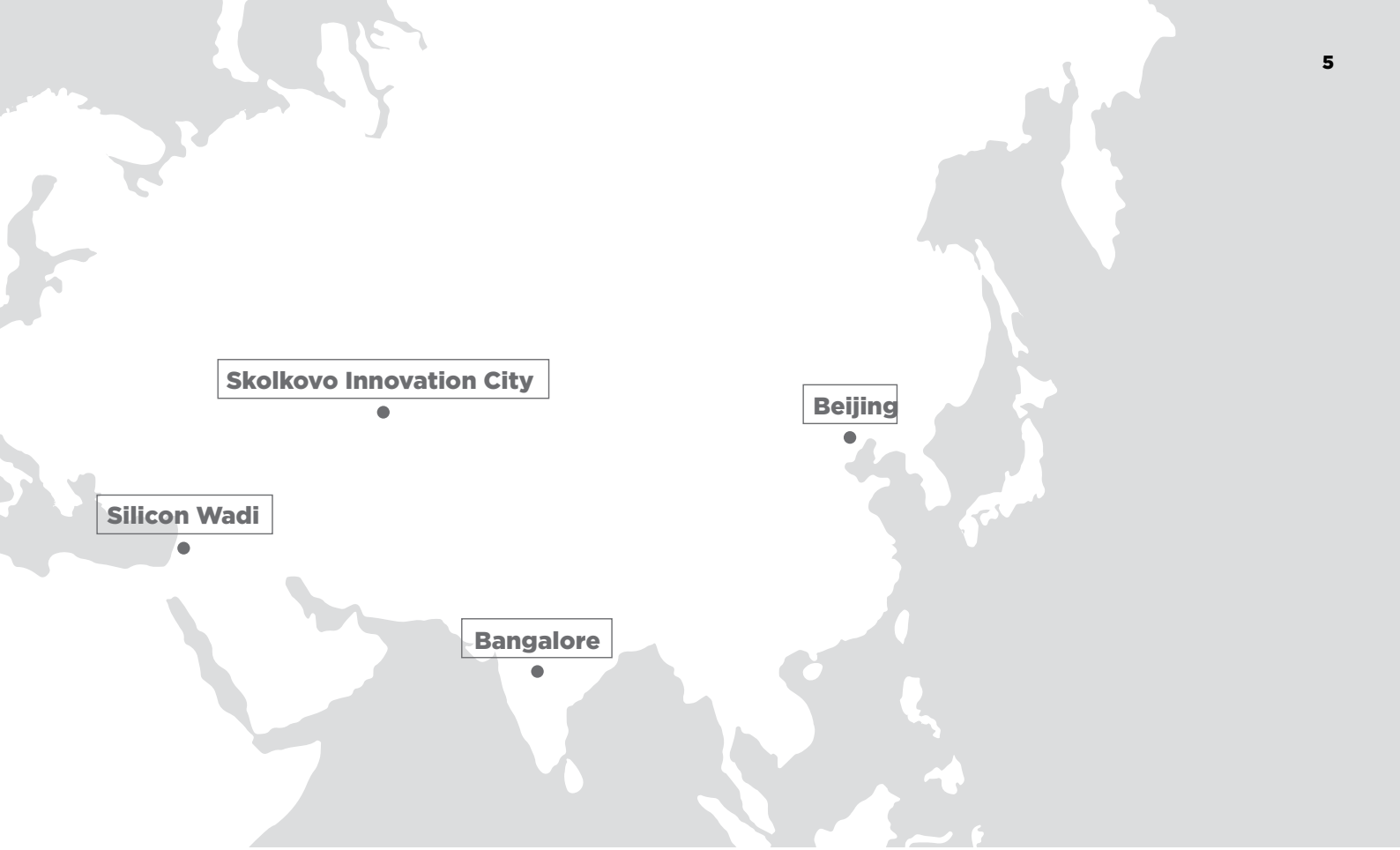
The wealth of resources and potential partners in the area makes Paris-Saclay one of the most attractive innovation hubs for investors, innovators, and entrepreneurs from all over the world:

- location in the heart of Île-de-France, Europe's leading economic region*;
- excellence of the training and research offer to the highest international standards supported by Paris-Saclay University and the Institut Polytechnique de Paris;
- abundance of large-scale scientific equipment and multidisciplinary laboratories;
- concentration, excellence and diversity of industrial players and start-ups;
- rare quality of life in a setting that values the natural environment.

Created in 2010 under the Greater Paris law, Paris-Saclay Development Authority (EPA Paris-Saclay) steers and coordinates the development of the science and technology hub with local players and promotes the cluster abroad. The cluster's development strategy is based on three pillars: support for innovation through the development of a community of companies, start-ups and innovation centers; promotion of the cluster's international appeal and

One of the most attractive innovation hubs in the world.

*Source: INSEE



its Paris-Saclay Innovation Playground brand; and the development of services to meet the needs of companies.

With this in mind, Paris-Saclay development authority is mobilizing and federating industrial and academic players around strategic sectors in order to strengthen the links between public and private research, promote innovation and entrepreneurship, and stimulate economic growth in the region. Six fields of excellence have been identified, analyzed and mapped: aeronautics-defense-security, AgriTech-FoodTech, energy-city-environment, future mobility, health, and digital technologies. This document is intended to present the energy-city-environment field of excellence.

6 STRATEGIC SECTORS

Aeronautics Defense Security

Airbus, Safran, Thales, Nexter, Arquus, etc.

16* start-ups
68 laboratories and platforms

#NewSpace
#Cybersecurity

AgriTech and FoodTech

Danone, Mondelez, Syngenta

77* start-ups
110 laboratories and platforms

#FoodFromTheFuture
#HealthNutrition
#SmartFarming

Energy City Environment

EDF, Bouygues, Colas

47* start-ups
123 laboratories and platforms

#EnergyStorage
#Biofuel
#SmartGrids

Mobility

Renault, PSA, Valeo, Fiat, etc.

12* start-ups
46 laboratories and platforms

#AutonomousVehicle
#Hydrogen
#PackedSystems

Health

Sanofi, LFB, IPSEN, GE Healthcare

146* start-ups
346 laboratories and platforms

#Microbiota
#GeneTherapy
#Oncology
#ConnectedHealth

Digital technologies

Nokia, Ericsson, HP, Dassault Systèmes, etc.

106* start-ups
252 laboratories and platforms

#AI
#QuantumPhysics
#IoT
#SmartManufacturing

*currently listed on Paris-saclay-startup.com

The energy transition, a social issue

Among the sectors of excellence in Paris-Saclay, the energy transition sector, with more than 30 major establishments and nearly 125 laboratories and technical platforms in the area, around 17,000 jobs and a growing number of innovative start-ups, is among the most dynamic. It is a real challenge for society, one that is becoming increasingly critical and widely recognized, and one of the most strategic at national and global levels.

NEARLY
125
LABORATORIES

30 major establishments, nearly 125 laboratories and technical platforms, and approximately 17,000 jobs in the Paris-Saclay region

The energy transition is a vast subject and a major systemic field that calls on multiple disciplines and involves innovations in science and technology as well as in the economic and societal fields.
Because of its size, the richness and diversity of its players, its very high degree of multidisciplinarity, and the density of its skills, the Paris-Saclay science and technology cluster now occupies a leading position in the field of energy in France.

In order to study the contours and priority issues, the Établissement public d'aménagement Paris-Saclay, in collaboration with Paris-Saclay TTO (SATT), has initiated a vast study of the area.

Who are the players who today keep this sector alive in the heart of Paris-Saclay?
What key technologies are deployed there?
What is its structure? What are its assets? What are its dynamics over time?
What are its innovative capabilities for the future?

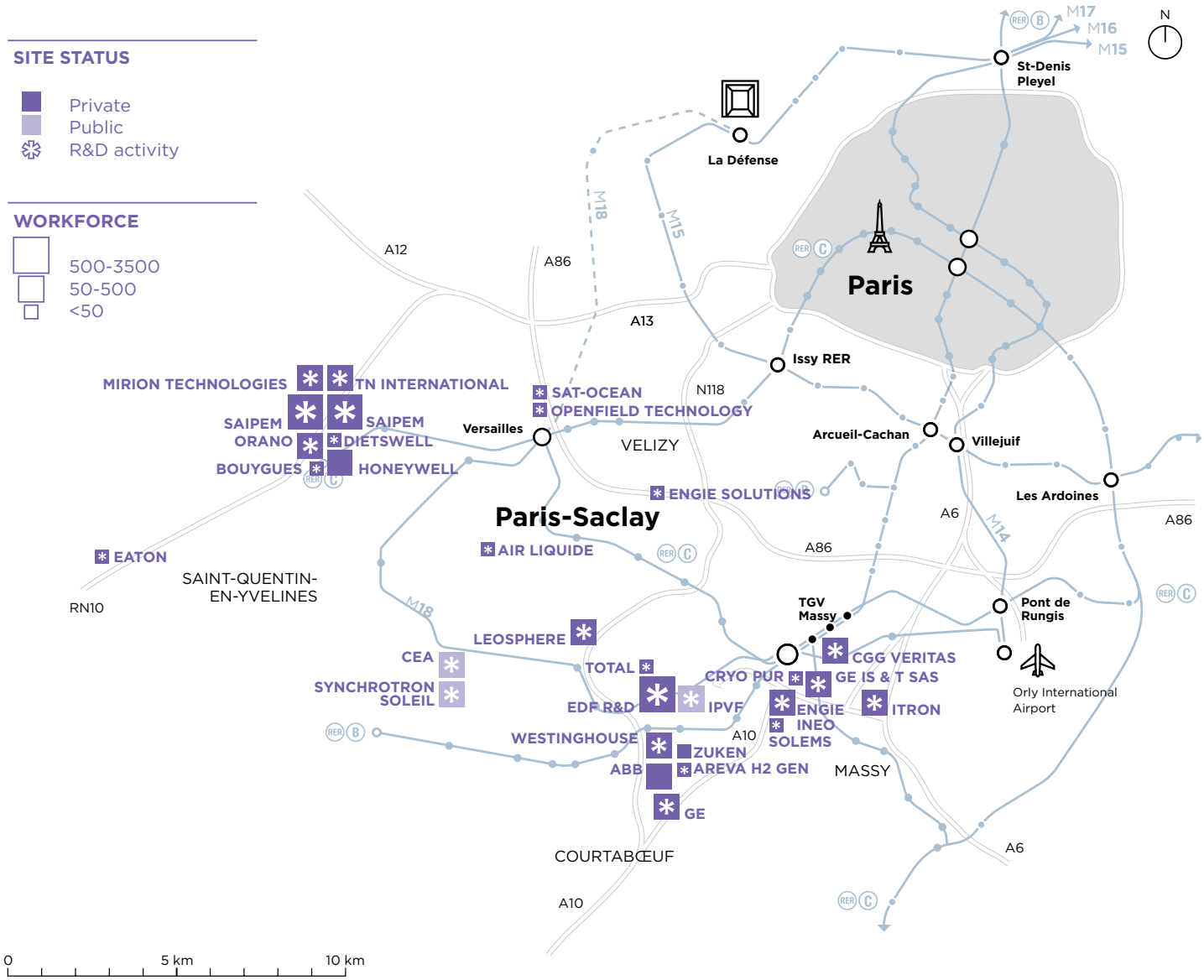
• **Fig. 1** Roofs of EDF Lab and Campus EDF, covered by solar panels.

The conclusions of this study, presented in this document, show that the region is a leader in bringing together world-class higher education institutions, internationally renowned research laboratories, international industrial groups and high-tech start-ups to create global excellence in research, industry and innovation.
Among its strengths: extensive research and training capabilities, the presence of world-leading energy companies, internationally renowned talent, strong synergies between research fields and technologies, and particularly innovative collaborative programs that are one of the hallmarks of Paris-Saclay.

Together, researchers, scientists and industrialists are collaborating and innovating in key energy sectors, particularly in the fields of the future such as hydrogen, bioenergy, photovoltaics, smart grids, geothermal energy and CO_2 capture.
These innovations will create the energy systems of tomorrow and place the Paris-Saclay region, itself an open-air demonstrator of the ecological and energy transition, at the heart of energy issues.

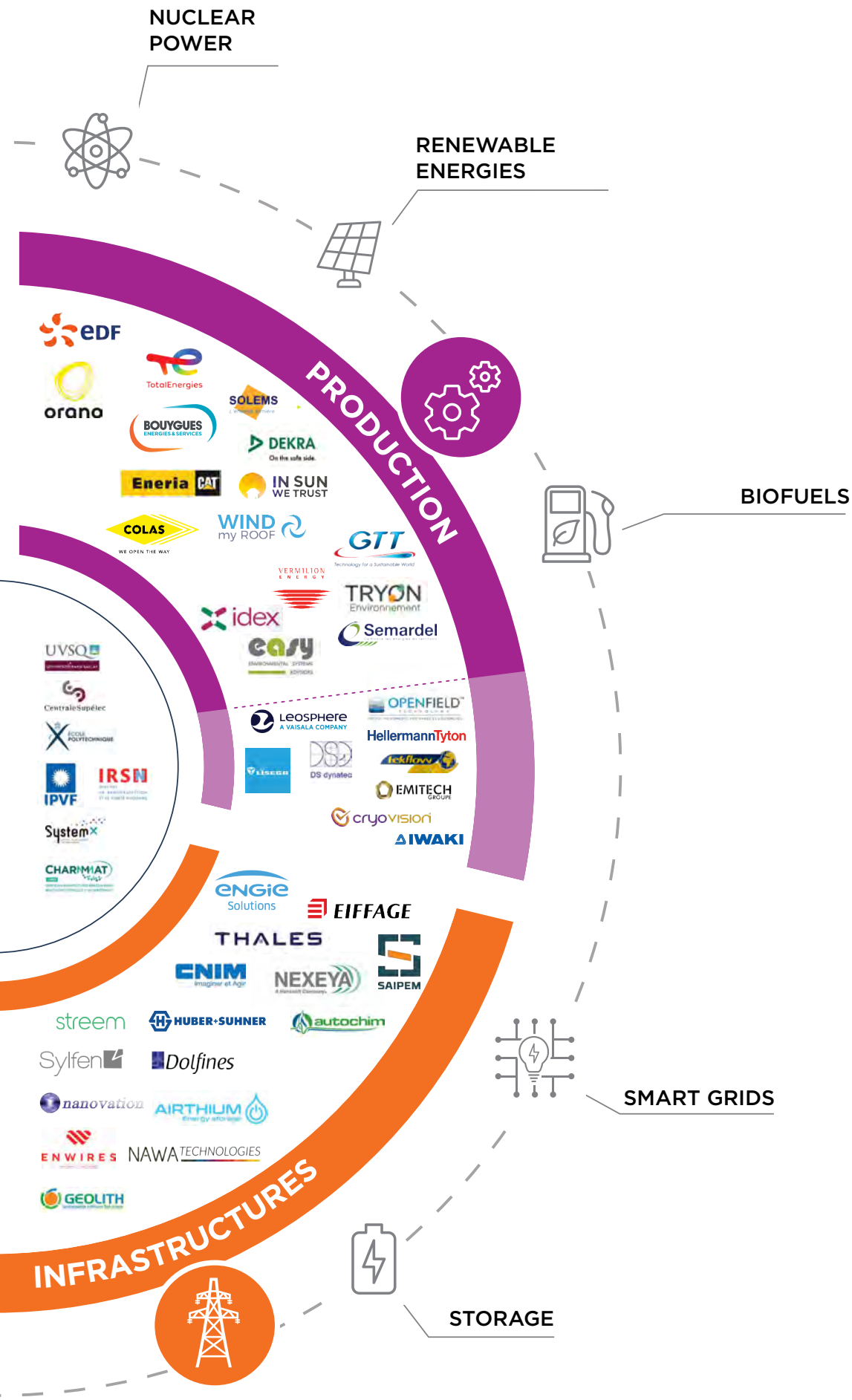
The Paris-Saclay science and technology cluster is now one of the leading energy clusters in France.

The energy sector in the Paris-Saclay region



Energy transition, a field of excellence within the Paris-Saclay cluster

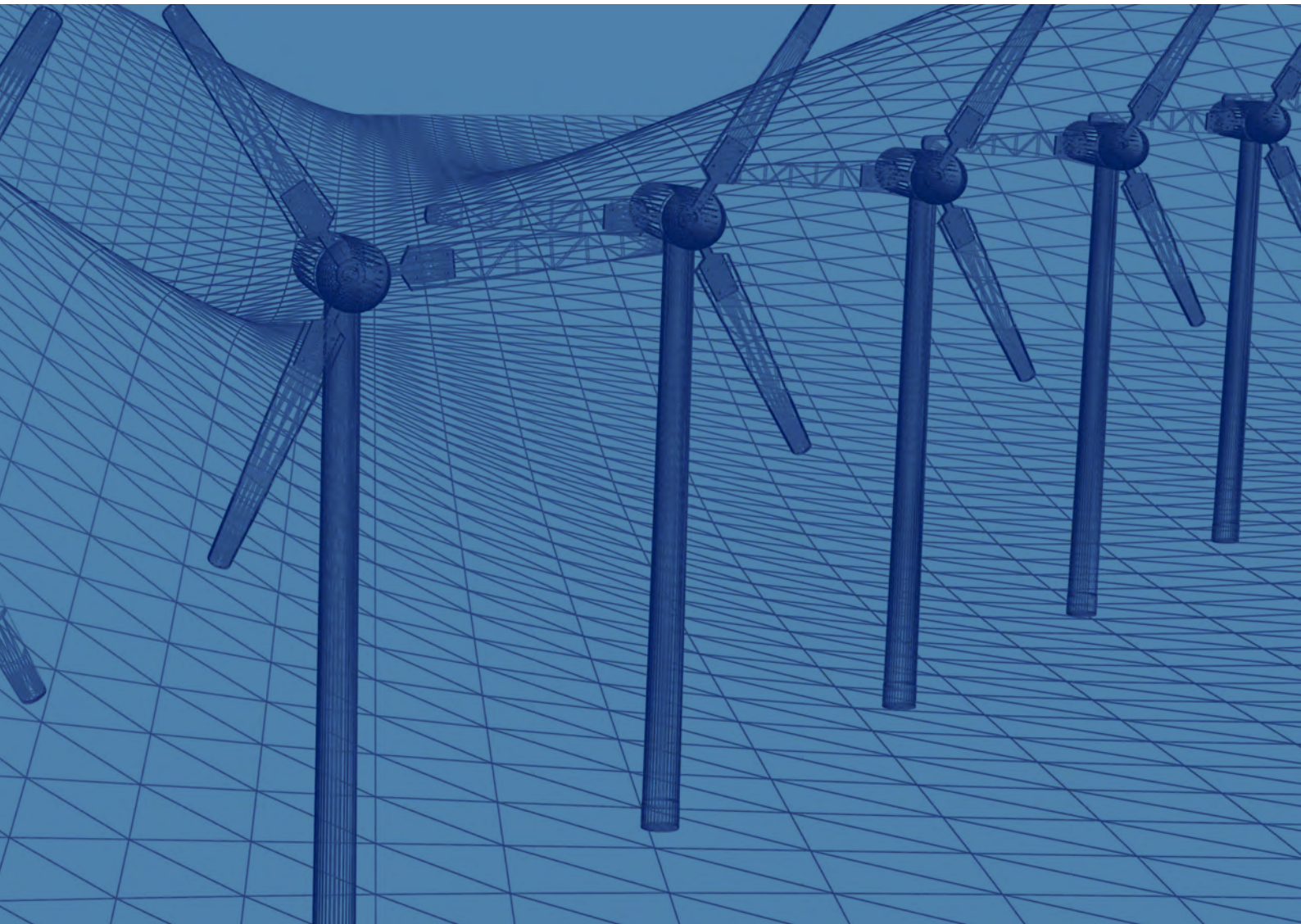
- A sector rich in players: world-class higher education institutions and research laboratories, international industrial groups and high-tech start-ups;
- A structured sector covering the entire energy value chain: production, infrastructure and uses;
- A sector positioned in the key technologies of tomorrow's energy systems: renewable energies, biofuels, nuclear power, smart grids, storage, hydrogen, energy efficiency, geothermal energy, carbon capture.


NUCLEAR POWER
RENEWABLE ENERGIES
BIOFUELS
SMART GRIDS
STORAGE
PRODUCTION
INFRASTRUCTURES
EDF
TotalEnergies
orano
SOLEMS
BOUYGUES ENERGIES & SERVICES
DEKRA
Eneria CAT
IN SUN WE TRUST
COLAS
WIND my ROOF
GTT
VERMILION ENERGY
TRYON Environnement
idex
Semardel
easy
UVSQ
CentraleSupélec
ECOLE POLYTECHNIQUE
IPVF
IRSN
SystemX
CHARMMAT
LEOSPHERE A VAISALA COMPANY
OPENFIELD
HellermannTyton
lisega
DS dynatec
tekflow
EMITECH GROUPE
cryovision
IWAKI
ENGIE Solutions
EIFFAGE
THALES
CNIM
NEXEYA
SAIPEM
streem
HUBER+SUHNER
autochim
Sylfen
Dolfines
nanovation
AIRTHIUM
ENWIRES
NAWA TECHNOLOGIES
GEOLITH

A research, education and innovation capacity unique in Europe

Among the key assets of the Paris-Saclay cluster, its academic multidisciplinarity, its concentration of major players, the strength of its skills and its size represent particularly structuring strengths for the plateau in the energy field.

This multidisciplinarity occurs first and foremost at a horizontal level, with a wide variety of disciplines studied and taught, strong synergies deployed between research fields and technologies, and a cross-disciplinary approach based on innovative collaborative programs. It is also active at a vertical level, from fundamental research to the innovation centers of leading energy groups, and includes training for students and professionals and raising awareness of the issues involved in the energy transition among young people.



Multidisciplinary and cross-disciplinary academic research

With the **Paris-Saclay University,** the **Institut Polytechnique de Paris,** the **Institut national des sciences et techniques nucléaires (INSTN),** the **Commissariat à l'énergie atomique et aux énergies (CEA**), the **CNRS** (French National Center for Scientific Research), and the **NanoSaclay, LaSIPS, P2IO and CHARMMAT laboratories of excellence (LabEx),** the Paris-Saclay cluster boasts some of the world's most prestigious and longest-standing higher education institutions and public research laboratories in the energy field.

It also relies on a strong interdisciplinary and cross-disciplinary approach, which is one of its greatest assets. A key example is the intersection of mathematical, digital and energy disciplines, for which the Paris-Saclay region has an exceptional number of leading players. The energy systems of the future include a growing number of digital technologies and critical issues in terms of performance and security that require specific academic and technological skills.

The Paris-Saclay cluster relies on strong interdisciplinarity and cross-disciplinarity, which is one of its greatest assets.

4 LABORATORIES OF EXCELLENCE DEDICATED TO ENERGY ISSUES

LabEx NanoSaclay

The LabEx NanoSaclay, a laboratory of excellence in nanoscience and nanotechnology, brings together more than 450 scientists working on the subjects of oxides for the electronics of the future, new concepts, nanostructured materials, devices and architectures for nanophotonics.

LaSIPS

LaSIPS, the systems and engineering laboratory of the Saclay plateau, brings together 550 researchers and a total of 1,540 people to develop innovative and cross-disciplinary activities in the field of engineering sciences and systems.

LabEx P2IO

The LabEx P2IO, for physics of the two infinities and origins, brings together 2,000 people, including 1,000 researchers, in the disciplines of particle physics, nuclear physics, astroparticles and astrophysics. This LabEx works in particular on the interdisciplinary theme of nuclear energy for the future.

LabEx CHARMMAT

The LabEx CHARMMAT, for chemistry of multifunctional molecular architectures and materials, is a project based on materials science and bio-inspired homogeneous catalysis. Its areas of expertise include emerging selective catalysis, emerging and innovative physical chemistry and spectroscopy techniques and materials science.

• **Fig. 2** Initial training on a nuclear reactor in virtual reality for students of the specialized engineering course in atomic engineering, on the INSTN Evoc Nuclear Experience platform.

Beyond its scientific and technological excellence, the value of the Paris-Saclay cluster lies in its ability to facilitate bridges between scientific and technological disciplines and, more generally, in its collective dynamics that promote cross-disciplinarity, multiculturalism and common understanding.

In this respect, three initiatives developed in recent years are exemplary: the **Sustainable Energy Institute** founded by the Paris-Saclay University, the **Institut Photovoltaïque d'Ile-de-France** and the **Energy4Climate** program initiated by the Institut Polytechnique de Paris. Based on synergies between disciplines, the co-location of skills and collaboration between academic and industrial players, these innovative collaborative and multidisciplinary programs are a true signature of the Paris-Saclay cluster. They enhance the cluster's skills and infrastructures and help build a systemic vision and intelligence of energy.

3

MAJOR COLLABORATIVE PROGRAMS DEVELOPED IN THE REGION

- The Sustainable Energy Institute
- The Institut Photovoltaïque d'Ile-de-France
- The Energy4Climate program

• **Fig. 3** Launch of the Sustainable Energy Institute at the Maison des Sciences de l'Homme on December 9, 2021.

A Sustainable Energy Institute for future energy systems

Emblematic of the collaborative programs developed in the field of energy, the Sustainable Energy Institute (IES) was created by the Paris-Saclay University in 2021. Complementing the University's offer in the field of sustainable energy and energy transition, structured around seven *Graduate Schools*, with cross-disciplinary programs based on societal issues, the Sustainable Energy Institute responds to the need to approach energy in a systemic and multidisciplinary framework.
At the heart of the research topics addressed in a technical, economic and societal manner: energy production from natural resources, energy storage and conversion, energy networks, uses and efficiency, and the links between energy and society.
The Institute brings together research teams from more than 40 laboratories, representing nearly 450 researchers and teacher-researchers, around these cross-disciplinary themes, and is developing some 20 partnerships with energy companies and competitiveness clusters in an approach that favors flexibility and collaboration.
Its objectives: to federate communities of expertise around research projects, to build common understandings between academic and industrial players on shared application issues, to develop technical platforms, to complement specialized teaching with more holistic training to understand the complexity of energy issues, and to become an attractive label for young people and companies sensitive to a systemic approach to energy issues.

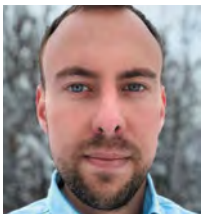
Energy4Climate Center: multidisciplinarity at the service of the energy transition

Initiated by the Institut Polytechnique de Paris and the École des Ponts-Paris Tech, the interdisciplinary Energy4Climate (E4C) center was created in June 2019 from an initial cross-disciplinary project named Trend-X. Carrying the ambition of responding to the challenge of energy transition in the face of climate change through research, teaching and innovation, the Energy4Climate center works on four major themes: decreasing greenhouse gas emissions, reducing energy consumption, deploying renewable energy, and selecting relevant public policies. Aiming to address the systemic complexity of the energy transition, the center mobilizes broad disciplinary fields ranging from social and economic sciences to materials science and engineering, including applied mathematics, computer science and geophysics. E4C has 26 laboratories working on these issues and is developing numerous relationships with energy companies, including EDF, TotalEnergies and Nam.R, a start-up specializing in building solarization. In September 2021, E4C published a white paper entitled "Energy and climate research perspective 2020-2025" to build an alignment of stakeholders on common objectives. The project carried by the Energy4Climate center is global. It includes master's, doctoral and continuing education, with an emphasis on interdisciplinary and entrepreneurial skills, and has an international dimension with the hosting of students and professors up to double degrees or the organization of summer schools. The center also offers access to test and demonstration platforms (smart grids, photovoltaic panel test benches) and a DataHub, a digital platform for sharing energy and climate data. In terms of infrastructure, the center has three intelligent buildings that serve as full-scale pilots to understand user behavior and predict energy consumption.

• **Fig. 4** An E4C achievement: the microgrid of the SIRTA climate observatory building operated by the Institut Pierre Simon Laplace, France's leading climate science institute.

INTERVIEW WITH LOÏC ASSAUD,
DIRECTOR, SUSTAINABLE ENERGY INSTITUTE**.**

The Sustainable Energy Institute, an interdisciplinary vocation



Encouraging interdisciplinary projects between researchers in the exact sciences, but also in the humanities and social sciences, in collaboration with industrial actors, around an energy that meets environmental, economic and social requirements, such is the vocation of the Sustainable Energy Institute (IES), inaugurated in 2021. Loïc Assaud, its director, who is also a teacher-researcher at the Institute of Molecular Chemistry and Materials at Orsay, in the "Research and Innovation in Electrochemistry for Energy" team, explains.

Before we get to the missions of the IES, can you tell us a little about where we are conducting the interview?

LA We are here in the IES premises, integrated in the fall of 2022, and located in the brand-new Henri Moissan building, designed by architect Bernard Tschumi [Agence BTuA], which houses the Biology, Chemistry and Pharmacy faculties of Paris-Saclay University. A location that allows for interaction internally, with the university's researchers and teacher-researchers, but also externally, with academic and industrial partners located in the Saclay plateau.

What motivated the creation of such an institute?

LA The IES was inaugurated in the wake of the official creation of the Paris-Saclay University, which was designed on the basis of a dual structure: on the one hand, around fifteen thematic *Graduates Schools* ranging from Chemistry to Law through "Geosciences, Climate, Environment, Planets", etc., and on the other hand, interdisciplinary institutes and programs with more cross-cutting themes related to societal issues, such as the IES, which is specifically designed to deal with energy, a field at the interface of many sciences, both exact and human and social. However, we were not starting from scratch: the creation of the IES was preceded by a Strategic Research Initiative (SRI), within the Paris-Saclay University, which was already working on energy issues.

Interdisciplinarity, you said, in the strong sense that you place yourself at the interface of very diverse sciences (exact, human and social), which it is not usual to cross even if one guesses the interest to do it in terms of energy. It is still necessary to create an appropriate space...

LA Energy refers as much to physical and chemical phenomena as to uses, acceptability issues (in this case of new technologies that are emerging), public policies, law, etc. It is everyone's business, from physicists, chemists, mathematicians, computer scientists, etc., to sociologists, economists, lawyers, etc. This is why we work in close collaboration with the Maison des Sciences de l'Homme (MSH) of the Paris-Saclay University, in order to cover both technical and societal issues. We have jointly launched a call for proposals for the funding of post-doctoral fellowships aimed at fostering the emergence of interdisciplinary research projects of excellence. Its theme is "the transformation of energy systems to meet today's major societal challenges".

> **"Energy is everybody's business – from physicists, chemists, mathematicians, computer scientists, etc., to sociologists, economists, lawyers, etc. This is why we work in close collaboration with the Maison des Sciences de l'Homme (MSH) of the Paris-Saclay University."**

What exactly does sustainable energy cover?

LA By sustainable energy, we mean decarbonized, and therefore renewable, energies. This is quite a broad scope, covering for example photovoltaics, wind power, biomass, hydrogen, etc. We also cover the entire chain, from production to final application, such as sustainable mobility, for example, including the conditions for storing and transporting gas, electricity and heat. Is it more economical to transport gas than electricity? Should it be converted on-site or off-site? These are some of the questions we are also asking. in addition, there are the problems of CO_2 conversion

and uses – which justifies this opening to the SHS that we mentioned.

How many researchers do you employ and what are their profiles?

LA The IES brings together research teams from some forty laboratories at the Paris-Saclay University, i.e. approximately 450 permanent researchers and teacher-researchers, plus doctoral students, post-doctoral fellows, engineers/technicians and contract workers.

Your themes are of interest to industrialists, who are themselves involved through their R&D. What are your interactions with them?

LA Industrialists have always shown an interest in academic research. This is especially true for the energy industry.
However, until now, it was not easy for them to identify the research teams and expertise available in our laboratories. They lacked a single point of contact to facilitate the connection. From this point of view, the IES fills a gap. Its role is that of facilitator: we connect our researchers with industrialists, whoever they may be: large groups, very small companies or start-ups from the university.
The Paris-Saclay ecosystem is particularly favorable: the energy sector already includes all the big names in the sector. Partnerships have long been established between the research community and industry, whether through chairs or other partnership structures. It is clear that the interactions between the two can only intensify, in view of the energy transition and the fight against climate change. Several of our laboratories have experience in technology transfer and commercialization. We work in close collaboration with Paris-Saclay TTO (SATT).

"The Paris-Saclay ecosystem is particularly favorable. Partnerships have long been established between the research community and industry."

What about training issues?

LA This is another aspect of IES's missions: we wish to propose new ones, always in partnership with industrialists, to prepare for the professions of tomorrow and to meet the needs for new technical skills and competencies expressed by these industrialists. We are working on a response to the "Skills and professions of the future" calls for expressions of interest launched as part of France 2030 with our industrial and academic partners, as well as with secondary school teachers, to cover training courses from undergraduate to doctoral level.

In addition, we have designed a MOOC, MOMEMTOM (for *"MOlecules and Materials for the Energy of TOMorrow"*), to provide additional training for students at the Paris-Saclay University, but not only: this MOOC is free, accessible online and, therefore, internationally (it is broadcast in English).

I cannot resist pointing out that the geographic proximity of your partners allows for decarbonized travel, even if your interactions extend beyond the perimeter of the ecosystem and the Paris-Saclay campus.

LA What you are pointing out here is anything but incidental. We cannot claim to promote sustainable energy if we do not set an example by ensuring the sustainability and therefore the decarbonization of our research activities. There is not a single action, right up to the international conference to be held here in March 2023, that we are not making exemplary with regard to sustainability and GHG emissions.

Interview by Sylvain Allemand

A "sustainable" conference

The IES intends to be exemplary even in the way it designs an international conference. ***"In concrete terms,"*** **explains Virginie Tallio, Research, Training and Innovation Project Manager, "we scrutinize** ***every aspect: from the transportation of participants to their departure, the course of the conference, the content of the catering - meals and breaks - not forgetting the choice of goodies! We are taking this conference as a real-life test, to learn from it for any other event. This approach is very important to us, as our intention is to go beyond the energy aspect alone. As the 'S' in its acronym indicates, the IES aims to make energy sustainable and, therefore, to understand it in its environmental, social and economic dimensions, in short, to have a holistic vision."***
More information on: https://momentom2023.sciencesconf.org/

A continuum of training from the younger generation to decision-makers

The issue of training is inseparable from research and innovation and is crucial to the future of the industry. Within the Paris-Saclay cluster, this takes place at several levels. For the youngest, the region has an undeniable attractiveness. As early as junior high school and high school, contact initiatives are developed to generate scientific and technical vocations. These include the **Île de Science Paris-Saclay** and **S-CUBE** programs initiated by the EDF Group to disseminate scientific and technical culture to middle- and high-school students and raise their awareness of energy-saving issues. In terms of higher education, the Paris-Saclay cluster has some of the most prestigious universities and grandes écoles in France, such as the **Paris-Saclay University,** the **Institut Polytechnique de Paris,** the **Institut national des sciences et techniques nucléaires (INSTN),** as well as cross-disciplinary programs dedicated to energy: the **Sustainable Energy Institute, Energy4Climate,** the **Institut Photovoltaïque d'Ile-de-France**.
At the other end of the spectrum, continuing professional education also represents a major asset for Paris-Saclay in order to meet the current challenges of renewing and adjusting skills in the energy field. Operated by major players in the region, including the **INSTN** and the **EDF Group,** it enables skills and industrial sectors to be adapted to the major technical and societal changes associated with the energy transition.

The issue of training is inseparable from research and innovation and is crucial to the future of the industry.

Continuing professional education represents a major asset for Paris-Saclay to meet the current challenges of renewing and adjusting skills in the energy field.

• **Fig. 5** Continuous training in the operation of PWR nuclear reactors on the C-PWR simulator provided by the INSTN for employees of the nuclear industry.

The INSTN, the school specializing in low-carbon energy and health technologies

At the crossroads of higher education and professional training, the Institut national des sciences et techniques nucléaires (INSTN) was created in 1956 to train engineers and researchers in the field of nuclear science and technology, in response to the needs of the emerging nuclear industry and nuclear medicine. Since its creation, its orientations have evolved in response to the industry's need for skills and to public policies on energy and health. Today, the INSTN, as a school specializing in low-carbon energy and health technologies, provides specialization and continuing professional education for operators, technicians, engineers and researchers in France and abroad, in the fields of low-carbon energy (nuclear energy and new energy technologies) and health technologies, particularly medical applications of nuclear energy and imaging. Administered by the French Atomic Energy Commission (CEA), the INSTN is organized into teaching units located at five sites in France: Cadarache, Cherbourg-Octeville, Grenoble, Marcoule and Saclay. In the area of degree training, the school is involved in more than 40 degrees (master's, professional degrees, engineering degrees) in addition to its own degrees in atomic engineering, radiological and medical physics, and radiation protection. In terms of continuing education, it trains employees of the region's major industrial players, including EDF, Orano, Assystem and the CEA, on the subjects of nuclear power for industry, health technologies and new energy technologies, such as hydrogen, smart grids and photovoltaics.

The INSTN also assists companies and governmental agencies in the reinforcement of their capacities and the development of their competences. Each year, the INSTN trains 1,400 students, including 300 apprentices, and 7,000 trainees in continuing education. It also administers nearly 1,600 doctoral students working in CEA laboratories.

1400 **STUDENTS TRAINED**

7000 **TRAINEES IN CONTINUING EDUCATION EACH YEAR**

• **Fig. 6** The INSTN is the school specializing in low-carbon energy and health technologies, affiliated with the CEA.

A concentration of industrial leaders in the sector

Attracted by the presence of internationally renowned research organizations and top engineering schools, and stimulated by the deployment of innovative collaborative programs, many of the world's leading companies in the sector have set up their research and development teams in the heart of the Paris-Saclay science and technology cluster. These include **EDF, TotalEnergies and Air Liquide,** three French energy giants, as well as **Bouygues énergies & services**, based in Guyancourt, **Westinghouse** based in Orsay, **Orano** based in Saint-Quentin-en-Yvelines, as well as **Dekra, Colas, Thales, Eiffage** and **Engie Solutions**. The presence of these energy leaders is a structuring force for Paris-Saclay and facilitates the process of transforming knowledge into applications along the innovation chain. It also has a positive knock-on effect on the emergence of SMEs and especially deep-tech start-ups in the region by providing attractive access to the resources and knowledge needed for tomorrow's energy systems.

3

FRENCH INDUSTRIAL ENERGY GIANTS IN THE REGION

- EDF
- TotalEnergies
- Air Liquide

Fig. 7 TheEDF R&D center.

EDF Lab, the largest R&D center in the world

Bringing together, since 2016, more than 1,200 researchers on a single site located in the heart of the Paris-Saclay urban campus, EDF Lab Paris-Saclay is the largest research and development center in the world. Adjacent to the EDF Campus, Europe's leading vocational training center in the energy sector, it includes a test hall, experimental laboratories, a conference center, a showroom and numerous creative and innovation acceleration rooms in four buildings that are exemplary in terms of energy and environmental performance.
On this large-scale site, EDF Lab Paris-Saclay brings together leading scientific expertise in the various fields of the energy sector: low-carbon electricity production, electrical systems of the future and new energy services.
At the heart of the region's open innovation dynamic, combining research, training and innovation, the center welcomes about a hundred doctoral students each year, while its researchers work in close collaboration with the major academic and industrial players on the plateau. The center has forged strong partnerships with the CNRS, the Paris-Saclay University and the Institut Polytechnique de Paris, where it is a strategic partner in the Energy4Climate program.
It has also developed joint laboratories, including the PGMO (Programme Gaspard Monge pour l'Optimisation et la recherche opérationnelle), which works with the Fondation Mathématique Jacques Hadamard, the management of production resources and smart grids, and the IMSIA (Institute of Mechanical Sciences and Industrial Applications), which is shared by EDF Lab Paris-Saclay, the CEA, the CNRS and ENSTA Paris-Tech and focuses on the durability of structures. RISEGrid is another of its joint laboratories, dedicated, in collaboration with CentraleSupélec, to the study and modeling of intelligent electrical networks.

TotalEnergies sets up its new R&D center in the heart of Paris-Saclay

Since 2018, TotalEnergies has been keen to locate its New Energy & Power research and development center in the heart of the Paris-Saclay scientific and technological ecosystem. As of 2022, this is a reality. This cluster is made up of 200 researchers and develops numerous collaborations with laboratories, universities, schools, companies and start-ups in the region. Among the partnerships initiated by TotalEnergies in recent years are the scientific partnership with the Institut Polytechnique de Paris around the Energy4Climate program *via* the "Technological Challenges for Responsible Energy" Chair and Hi! PARIS on artificial intelligence and data sciences or the partnership developed with the Laboratoire de Physique des Interfaces et des Couches Minces (LPICM) on photovoltaic solar energy. Since 2013, TotalEnergies has also been a founding member of the Photovoltaic Institute of Île-de-France, which brings together major French industrialists, equipment suppliers and academic partners. Since 2019, it has also been a member of Vedecom, an institute for energy transition dedicated to the mobilities of the future. Finally, in 2020, the group created the SINCLAIR joint laboratory with EDF and Thales, dedicated to artificial intelligence.

Many of the world's leading companies in the sector have set up their research and development centers in the heart of the Paris-Saclay cluster.

Innovation Campus: a major R&D center for Air Liquide

Air Liquide's Paris Innovation Campus houses, among other company structures, the first of the Group's R&D centers, with more than 350 researchers, 59 laboratories and 8 technical platforms on 15,000 m². It embodies the group's open innovation, particularly in the area of energy transition, partnerships with major local research laboratories (CNRS, Paris-Saclay University and the Institut Photovoltaïque d'Ile-de-France, of which it is a founding member), start-ups and industrial players such as Arkema and Airbus, as well as with the Additive Factory Hub, an additive manufacturing platform created in 2017 on the Saclay plateau. Committed to innovation in the region, the campus also hosts a deep-tech start-up accelerator, Accelair, which, since 2019, has been offering offices, access to individual experimentation spaces and a customized support program by putting companies in touch with Air Liquide experts with the aim of accelerating the industrialization of their offer.

• **Fig. 8** Air Liquide's Paris Innovation Campus. View of the new building inaugurated in Les Loges-en-Josas in September 2018.

INTERVIEW WITH LUCIE PROST
DIRECTOR OF AIR LIQUIDE'S PARIS INNOVATION CAMPUS

Open innovation at the service of the energy transition

In September 2018, Air Liquide inaugurated a "campus" on its historic site in Loges-en-Josas, designed with an open innovation approach with the industrial and academic players of the Paris-Saclay ecosystem. Lucie Prost, its director since September 2022, explains its ambitions in terms of energy transition, particularly in the hydrogen sector.

We are here on the historic Air Liquide R&D site, which has been transformed into the Paris Innovation Campus. Why choose the word "campus"?

LP This site in Loges-en-Josas is indeed historic: we have been there since the 1970s. It has just undergone an extensive renovation that resulted in the construction of new buildings inaugurated in September 2018 - test halls still remain from the old site. Future investments are planned in the Croix Blanche sector to accommodate other group entities. Our campus has 48 laboratories and pilot platforms.
So why talk about a campus? Because, in addition to developing our R&D activities, we want to have a place that brings together other entities and skills of the Air Liquide Group that contribute to innovation, as well as academics - we welcome doctoral students under a Cifres or work-study agreement - and start-ups - our campus has a deep-tech accelerator, Accelair, inaugurated in 2019. To date, nine start-ups have been hosted there, five of which are still being accelerated. They have access to our equipment (laboratories, pilot platforms, 3D printers, etc.) for their tests and prototypes, while benefiting from the advice of our research engineers.

A word about the architectural design of your campus, which is obviously intended to encourage the cross-fertilization of skills...

LP Indeed. Designed by architects Michel Rémon & associés, our campus was conceived to encourage interaction both internally and with the outside world, in a spirit of open innovation. The first floor is organized, from the main entrance, around a hall accessible to the outside public, then an "artery" where all staff, both administrative and laboratory, are brought together. The rotunda through which you arrived can accommodate internal or external events, with a capacity of 300 people. in addition, there is an auditorium with a hundred seats.

A word about the Paris-Saclay ecosystem. How does your campus interact with it?

LP We have a long-standing relationship with the higher education and research institutions of Paris-Saclay, starting with the engineering schools: CentraleSupélec, École polytechnique, etc. We also have close relations with the national research organizations located there - the CEA and the CNRS. We have also joined forces with the Institut Photovoltaïque d'Ile-de-France (IPVF), a more recent creation. We are also involved in the national Confiance.ai program, which aims to industrialize artificial intelligence through a secure platform that will allow data to be pooled for innovative industrial projects. It brings together nearly forty academic and industrial partners, many of whom are present in the Paris-Saclay ecosystem (Renault, Safran, Thales, the IRT SystemX, Inria, etc.).

> **"We have a long-standing relationship with the higher education and research institutions of the Saclay plateau."**

What is the focus of your research and innovation in the energy field?

LP Our research and innovation activities focus on at least two major issues. On the one hand, the management of CO_2 emissions with a view to the decarbonization of industrial activities, both our own and those of our customers and partners. To this end, we have a portfolio of technologies (CryocapTM) for capturing, purifying and liquefying CO_2 - in other words, *carbon capture/use/storage* processes - which we are working to optimize while characterizing new use cases, particularly in the food industry.
On the other hand, the production of liquid hydrogen to meet the needs of heavy transport, i.e. by truck, ship, train or plane. We have already established partnerships with transport operators and

manufacturers to provide them with technological solutions for the safe use of hydrogen throughout the logistics value chain.

Could you give a specific example?

LP Our employees are involved in the hydrogen aircraft project led by the Airbus group. It plans the first tests in 2027 for commercial flights by 2030. Many other fields of application for hydrogen are possible, such as industrial production processes requiring the use of furnaces - metallurgy, glass-making, etc. The use of hydrogen not only boosts the temperature but also does not emit GHGs - for the moment, these furnaces use methane (CH_4), which emits a lot of CO_2, whereas the combustion of hydrogen produces only water and nitrogen.
But the use of this hydrogen begins right here on our campus, which has a station that supplies not only the vehicles in our fleet, but also the buses of two lines of the Versailles Grand-Parc agglomeration community and the Hype cabs.

I can just imagine the range of expertise and skills mobilized on your campus...

LP In fact, we have engineers at PhD or post-doc level, specializing in gas and combustion analysis; in characterization and behavior of materials at very low or very high temperatures; in processes, in life sciences applied to agri-food or water treatment, etc. In addition, there are technicians who carry out characterization manipulations on our test benches. That's some 350 people, not counting the experts in various fields who work throughout the group.

To what extent does the energy crisis we are going through support your choices?

LP The choices we have made allow us to be in phase with current expectations and to prepare for the future, particularly thanks to hydrogen. We have been investing in this energy for years. Air Liquide was one of the founding members of the Hydrogen Council, an international consortium of leading energy and transportation companies with the ambition of investing in the hydrogen economy.
That being said, let's keep in mind that we are still in areas of uncertainty. This is why it is important to adopt a partnership approach, especially on a European scale. We are also encouraged by the European Union, which has been a forerunner in all the challenges of decarbonization of industry and continues to take initiatives in this direction.
Our R&D is already involved in several European industrial projects designed to decarbonize industry while meeting its energy needs.

"We offer technological solutions for the safe use of hydrogen throughout the logistics value chain."

In addition to the research and innovations you are conducting, how does your campus set an example in terms of energy?

LP Our buildings are at a high energy performance level. Newer buildings are based on a bioclimatic design - they do not use air conditioning, but natural ventilation. In addition, the campus is equipped with 300 m² of photovoltaic panels and is supplied with 100% biomethane natural gas and 100% renewable electricity.

Until recently, you were CEO of Air Liquide Santé and then of VitalAire. What predisposed you to direct the Air Liquide campus?

LP In addition to healthcare, my career at Air Liquide has been focused on industrial customer relations. These are directly concerned by the issues of energy transition and decarbonization. The same is true of the energy transition as it is of health, another area of research and innovation invested in by our campus: these are major challenges that give full meaning to the commitment of our employees. Just as the COVID-19 crisis was an opportunity for them to demonstrate the essential role of support for hospitals and patients, so the energy crisis gives full meaning to our R&D and innovation activities in the fields of hydrogen and decarbonization. And then, as I said, Air Liquide's Paris Innovation Campus is involved in international projects. It covers a vast area including Europe, Africa, the Middle East and India, which makes it the largest campus of the group, including in terms of staff numbers. This means that the prospects in terms of industrial and academic partnerships are numerous and stimulating.

Interview by Sylvain Allemand

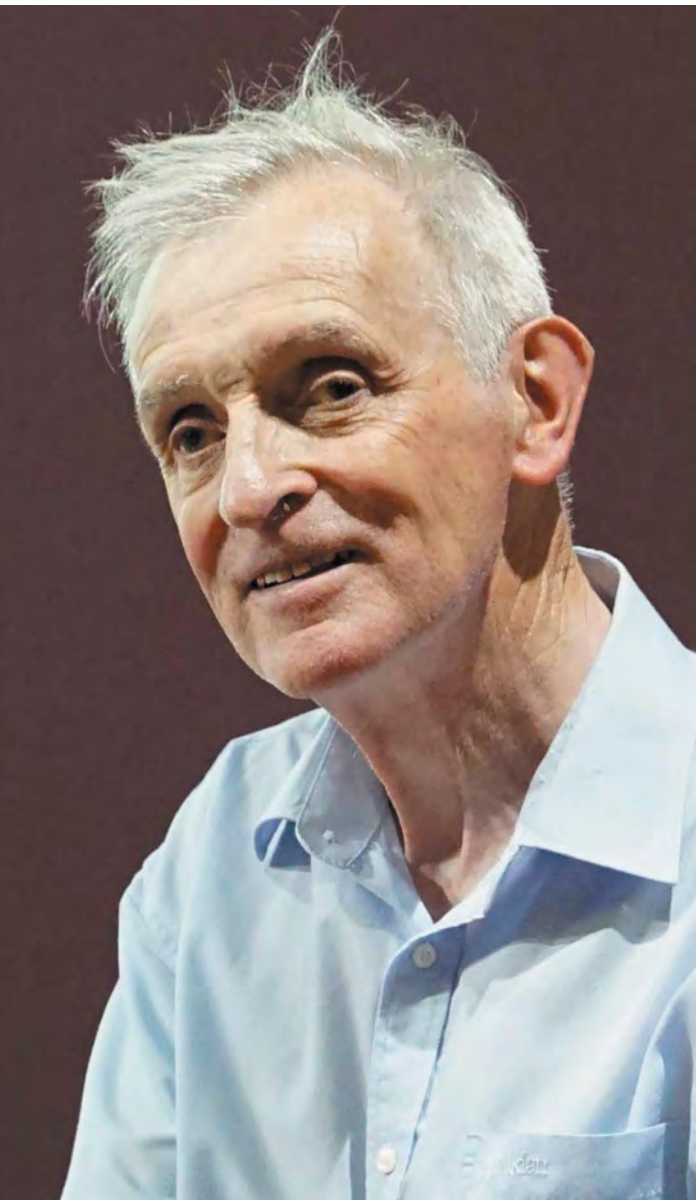
Talent of international renown

The prospect of working in world-class research establishments and laboratories and collaborating with both prestigious researchers and leading industrialists is encouraging an increasing number of scientists to join the Paris-Saclay academic cluster. According to the Highly Cited Researchers ranking, which lists the world's most cited scientists each year, France is in eighth place, with 36 scientists in the top 1% of their discipline at Paris-Saclay University. **Daniel Lincot,** professor at the Collège de France, silver medalist of the CNRS in 2004 and scientific director of the Institut Photovoltaïque d'Ile-de-France until 2019, is one of these researchers recognized worldwide by his peers. Since 1978, he has been renowned for his expertise in photovoltaic solar energy, a subject on which he has produced more than 300 publications and filed 22 patents. He has also participated in the creation of major organizations in the region, such as the Institute for Research and Development on Photovoltaic Energy (2005-2018) or the Institut Photovoltaïque d'Ile-de-France. **Jean-Michel Lourtioz,** Emeritus Research Director at the CNRS and Honorary Vice-President of the Paris-Saclay University, is known for his research in the fields of lasers, optoelectronics, photonic crystals and nanobiotechnologies. He has contributed to the creation of major structuring projects on the

36

SCIENTISTS IN THE TOP 1% OF THEIR DISCIPLINE

within the Paris-Saclay University according to the Highly Cited Researchers ranking, which places France in eighth place.



Jean Jouzel, Nobel Prize winner and world leader in climate research

Jean Jouzel is a world-renowned climatologist who began his career at the French Atomic Energy Commission (CEA). He owes his first success to the Vostok project, which saw the discovery of a 200-meter layer of ice under the sub-glacial lake of the same name in Antarctica. On the strength of this success and that of the Grip drilling program, Jean Jouzel set up the Epica program, which consists of drilling in the Antarctic, and became its director from 1995 to 2001. At the same time, he held various positions within the CEA and CNRS, including that of director of the climate and environment modeling laboratory and then head of the climate group within the Laboratoire des Sciences du Climat et de l'Environnement (LSCE) at the CEA.

From 2001 to 2008, he was director of the Institut Pierre-Simon Laplace, a federation of eight laboratories working on climate issues within the Paris-Saclay cluster. In 1994, Jean Jouzel joined the Intergovernmental Panel on Climate Change (IPCC), of which he was Vice-Chairman of the Scientific Council between 2002 and 2015. In 2002, the CNRS awarded him, jointly with Claude Lorius, its gold medal, the highest distinction for scientific research in France. In 2007 he was co-recipient of the Nobel Peace Prize with the IPCC, and in 2012 he received the Vetlesen Prize, considered the Nobel prize for earth and universal sciences. He is also one of the most quoted authors in the field of the sciences of the universe.

• **Fig. 9** Jean Jouzel in 2019, at a conference in Reims.

Paris-Saclay campus, such as the Centre de Nanosciences et de Nanotechnologies (C2N), as well as to the dissemination of scientific culture in the field of nanoscience and sustainable development. He has also initiated numerous cooperations with the industrial sector, particularly in the fields of microelectronics and optical telecommunications. Together, they participated in the creation of the start-up SQY PV in 2021, which manufactures flexible photovoltaic panels. Other major academic figures contribute to the prestige of the Paris-Saclay science and technology cluster. These include: **Marc Petit,** a teacher-researcher at CentraleSupélec in the field of electrical systems and coordinator of innovation and partnership actions within the Sustainable Energy Institute, **Philippe Drobinski,** director of research at the CNRS, professor at the École polytechnique, director of the Dynamic Meteorology Laboratory and founding director of the Energy4Climate center, and **Valérie Masson-Delmotte,** who is widely recognized nationally and internationally for her expertise on global warming, as well as **Nobel Prize winners Gérard Mourou and Jean Jouzel**.

2

NOBEL PRIZE WINNERS

- Gérard Mourou, Nobel Prize for Physics in 2018
- Jean Jouzel, co-recipient of the Nobel Peace Prize in 2007 with the IPCC

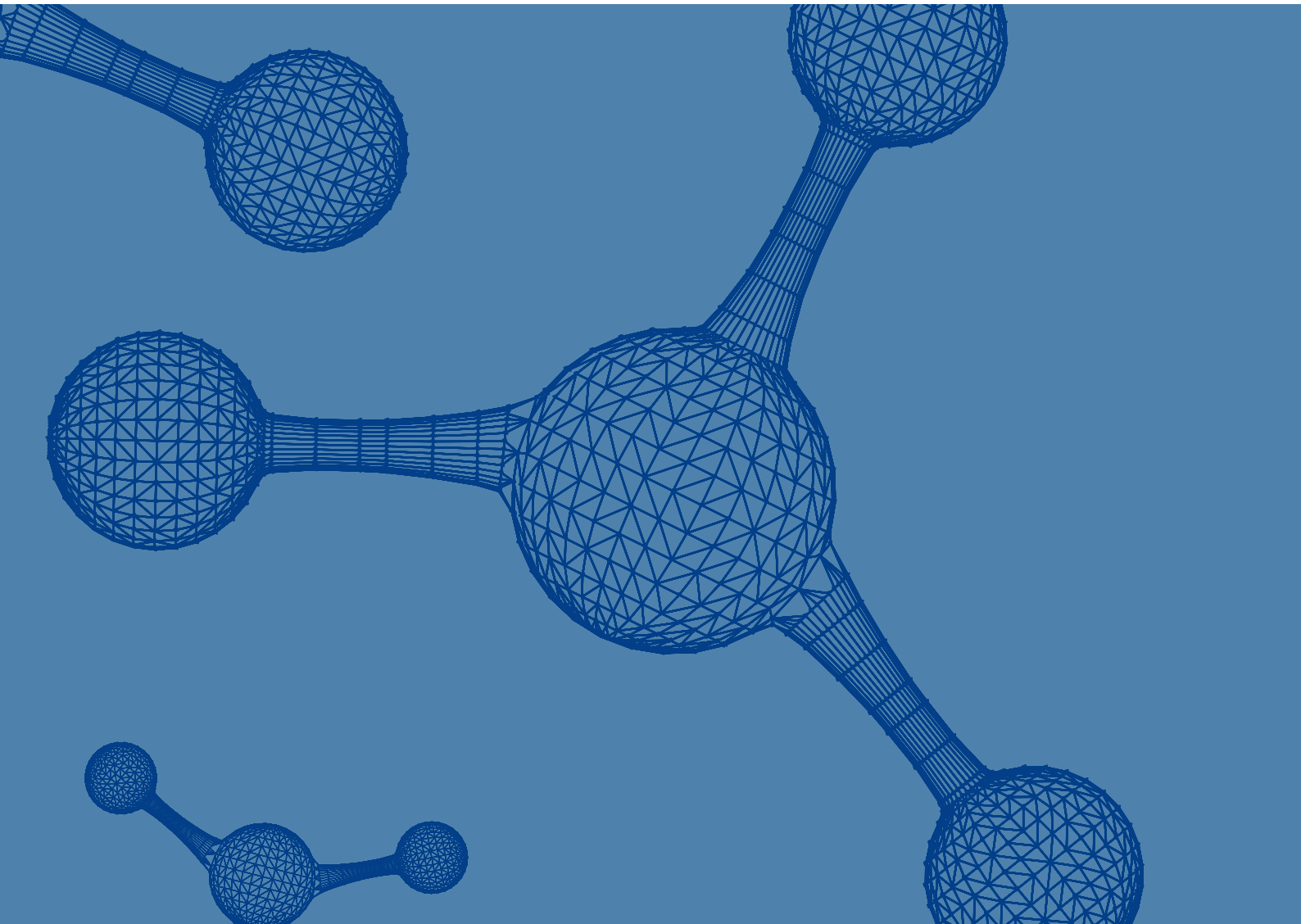
The prospect of working in world-class research establishments and laboratories and collaborating with both prestigious researchers and leading industrialists is encouraging an increasing number of scientists to join the Paris-Saclay academic cluster.

• **Fig. 10** Valérie Masson-Delmotte, research director at the Laboratoire des Sciences du Climat et de l'Environnement (LSCE) within the CEA.

Valérie Masson-Delmotte, Senior Representative of the IPCC

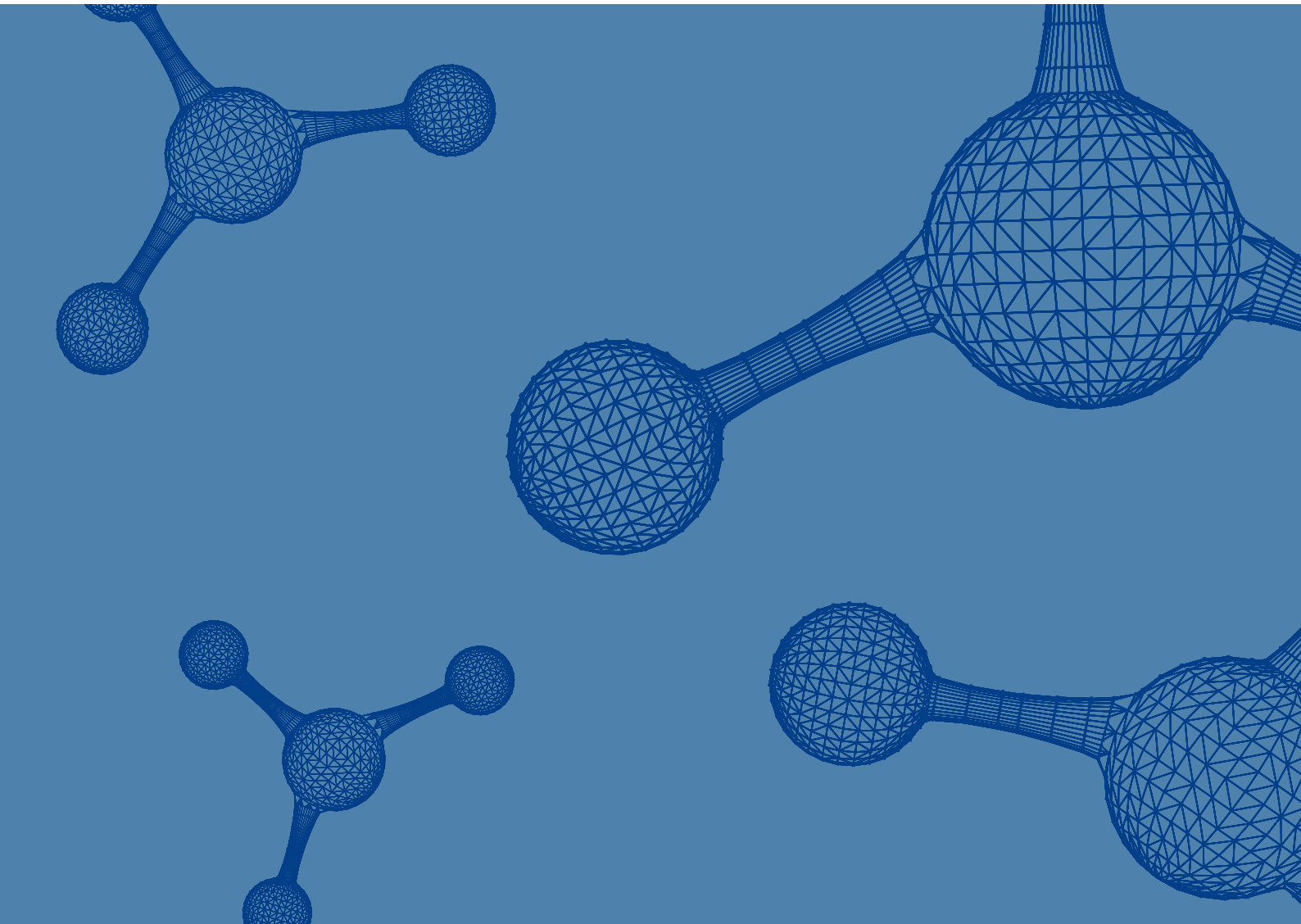
A climatologist with a degree in fluid and transfer physics from CentraleSupélec and research director at the CEA's Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Valérie Masson-Delmotte, who started out working alongside Jean Jouzel, focuses her research on climate change, particularly the evolution of past climates and the impact of future climate.
A member of the Intergovernmental Panel on Climate Change (IPCC), since 2015 she has been co-chair of Panel #1 on the physics of climate change. In 2018, she was ranked by the renowned scientific journal *Nature* as one of the ten most important people of the year. In 2019, she was the recipient of the CNRS silver medal. She is also a member of the High Council for the Climate, which reports to the French Prime Minister.

A position at the forefront of innovation in key technologies



With the wealth and diversity of its players, the density of skills deployed and a significant cross-disciplinary approach that has led to some of the most disruptive innovations, Paris-Saclay is at the heart of the energy challenges.

Its players - researchers, scientists and industrialists - are working on all of the key energy sectors, particularly on the sectors of the future, such as hydrogen, bioenergies, infrastructure and smart grids, geothermal energy and CO_2 capture. All of this encourages the creation of start-ups at the cutting edge of technology.



The leading energy sectors represented

With regard to the players present on the Paris-Saclay plateau, the three major fields of activity in the energy sector, namely production, infrastructure and uses, are particularly well represented.

First of all, in terms of **production**, which includes nuclear, fossil fuel, hydraulic and renewable energies such as solar, wind, geothermal and marine energy, the region has major energy producers such as such as **EDF, Orano, TotalEnergies, Bouygues Énergies & Services, Colas** and **Dekra**. Alongside these French industry leaders, SMEs and start-ups are active in the photovoltaic sector, such as **In sun we trust** or **Solems**, or in the wind power sector, such as **Wind my roof**. Regarding the production of bioenergy - biogas, biomethane, bioethanol or biodiesel - we should mention the start-up **Tryon**, which proposes local and modular methanization to recycle food biowaste, or the SME **Semardel**, which covers an activity in biogas.

In terms of **infrastructure**, the region has several companies in the fields of smart grids, energy transport, battery, mechanical or heat storage and hydrogen. Among the big names in the sector are **Engie Solutions, Thales, Eiffage,** the **CNIM group, Dolfines, Sopemea, Elogen** and **Air Liquide**. The sector also includes many start-ups that have emerged from innovations in the Paris-Saclay laboratories or have been established in the region, such as **Checkin, WinMS, Geolith, Nanomakers, Nawa Technologies, Airthium and Adionics**.

Lastly, **uses** cover both carbon capture and utilization activities - fossil electricity production with CO_2 capture, biofuel and hydrogen production, refining, chemical, metal and cement production - and everything related to energy efficiency in the building, lighting, heating, industry and electronics sectors.. In this field too, alongside major players such as **Bouygues Construction, Socotec** and **Cementys,** many start-ups are offering innovations at the heart of the energy transition. These include: **Enogrid, Kipsum, Dataswasi, Lemon Energy, Hello watt, Green Communications, Accenta, Ecojoko** and **Cryo Pur**.

3

MAJOR FIELDS OF ACTIVITY OF THE ENERGY SECTOR REPRESENTED

- Production
- Infrastructure
- Uses

• **Fig. 11** The Paris-Saclay cluster is a major research area for photovoltaics.

Production, infrastructure, uses: the three key sectors of the energy transition

The mapping of the energy transition is divided into three main areas of activity: production, infrastructure and uses.

The production sector covers several low-carbon power production activities:
- nuclear power,
- hydraulic energy,
- Renewable energies (ENR) including solar energy (photovoltaic and solar thermal), wind energy (onshore and offshore wind), geothermal energy and marine energy,
- bioenergies with biogas, biomethane, bioethanol, biodiesel.

The infrastructure sector includes various fields:
- digital infrastructures,
- smart grids,
- electric charging stations,
- flexible high-voltage current,
- storage (battery storage, mechanical storage, hydrogen storage).

The sector of uses, finally, covers many fields, of which the main ones are:
- industry,
- buildings,
- transportation,
- digital,
- lighting,
- heating and air conditioning.

• **Fig. 12** The Paris-Saclay region is home to the leading energy sectors, particularly those of the future such as hydrogen.

A major role in key technologies

The key trends in the energy market are emerging around the major challenges of the energy transition: **low-carbon electricity production, storage, energy efficiency, hydrogen, bioenergies, infrastructures and grids, geothermal energy and CO_2 capture**. These major orientations will structure the industry worldwide in the coming years. They are already stimulating research, innovation and major collaborations between academic and industrial players within the Paris-Saclay cluster.

One of Paris-Saclay's historic strengths is its cutting-edge research on key nuclear technology. With the French **Commissariat à l'énergie atomique et aux énergies alternatives (CEA)**, Paris-Saclay is at the heart of nuclear research in France. Opened in 1952, at the time close to the new scientific university in Orsay, the CEA site in Paris-Saclay today houses more than 7,000 people in one of the largest scientific research centers in Europe, spread between Fontenay-aux-Roses, Saclay, Orsay and Evry.

7

KEY ENERGY MARKET TRENDS

- Low-carbon electricity production
- Storage
- Energy efficiency
- Hydrogen
- Bioenergy
- Infrastructure and grids
- Geothermal energy and CO_2 capture.

The Institut Photovoltaïque d'Ile-de-France: the leading edge of global solar energy research

At the interface of the academic and industrial worlds, the Institut Photovoltaïque d'Ile-de-France (IPVF) was founded in 2014 around a partnership between three academic players - CNRS, École polytechnique, Chimie ParisTech - and five industrialists - TotalEnergies, EDF, Air Liquide, Horiba and RIBER. Its objective is to improve the performance and competitiveness of photovoltaic cells, in particular by developing breakthrough innovations. Its ambition is to become one of the world's leading centers for research, innovation and training in the field of photovoltaic solar energy. With this in mind, the Institute brings together internationally recognized academic research teams and leading manufacturers in the photovoltaic industry in a collective initiative. The associated Joint Research Unit (UMR) carries out fundamental research in the sector and participates in numerous courses in graduate, master's, continuing education and doctoral schools. Involved in various collaborations with laboratories at the CNRS, the École polytechnique, and Chimie ParisTech, the IPVF is responding to one of the main challenges in the field: building a bridge between the academic and industrial worlds around a particularly strategic sector.

• **Fig. 13** The Institut Photovoltaïque d'Ile-de-France brings together scientific and technological excellence and world leaders in renewable energy deployment.

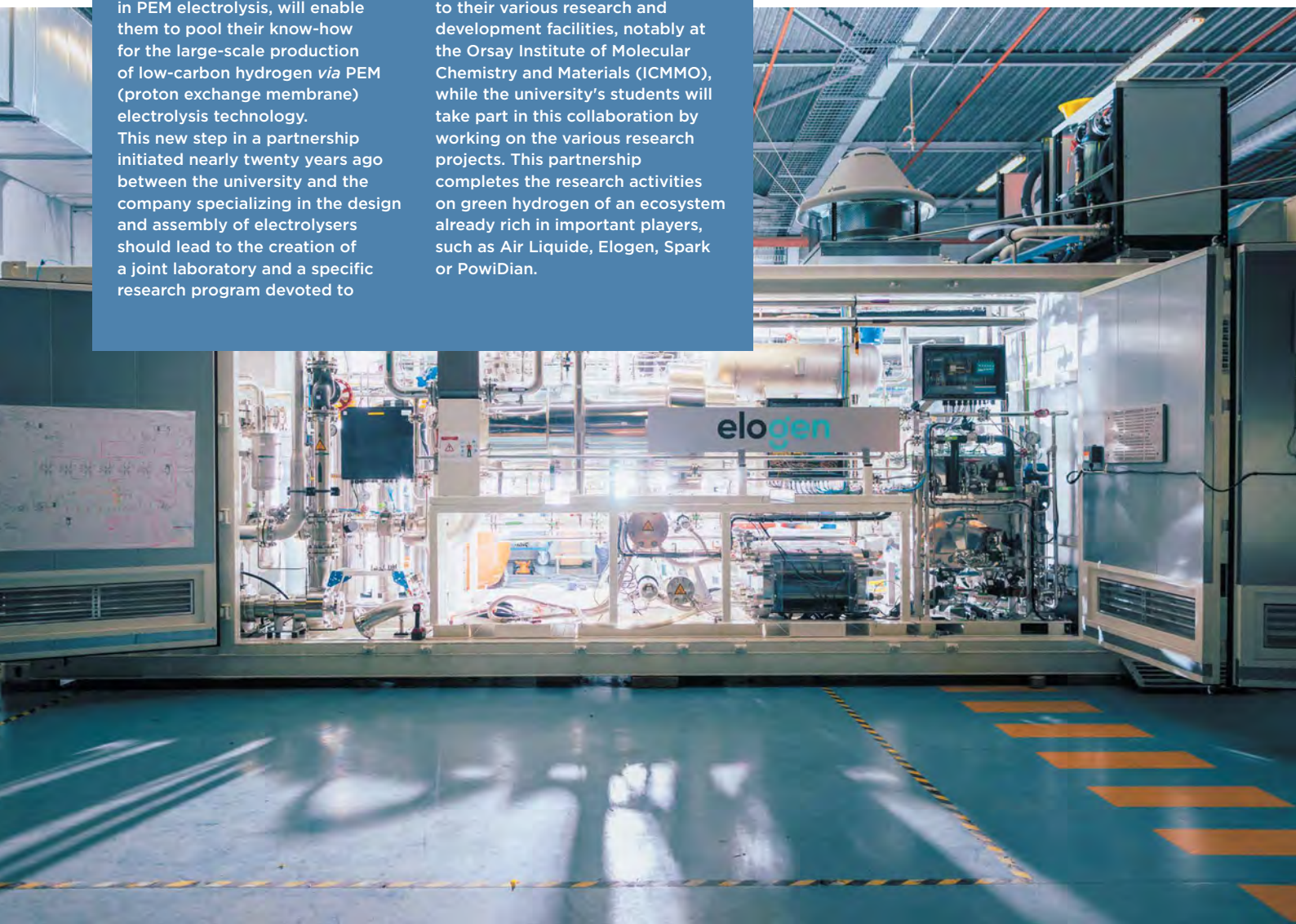
The CEA is at the heart of French nuclear and fundamental research, particularly in nuclear and neutron physics, but also in astrophysics and nuclear medicine. Over the years, it has expanded its missions to include themes with high societal stakes, such as technologies for industry, renewable energies and climate and environmental issues.

The Paris-Saclay cluster is also particularly well positioned in terms of research into photovoltaics, electrolysis and hydrogen. On these themes, Paris-Saclay relies in particular on two particularly innovative collaborative programs: **the Institut Photovoltaïque d'Ile-de-France (IPVF) and the collaboration agreement between Elogen and the Institute of Molecular Chemistry and Materials at Orsay (ICMMO).** Both, cultivating synergies between disciplines and based on a very strong collaboration between public and private actors, participate in scientific and technological advances and make the Paris-Saclay cluster a key player for these future technologies.

Paris-Saclay is particularly well positioned in terms of research into the future technologies of photovoltaics, electrolysis and hydrogen.

Paris-Saclay University and Elogen produce low-carbon hydrogen

The collaboration agreement signed on December 3, 2021 between the Paris-Saclay University and Elogen, the French leader in PEM electrolysis, will enable them to pool their know-how for the large-scale production of low-carbon hydrogen *via* PEM (proton exchange membrane) electrolysis technology.
This new step in a partnership initiated nearly twenty years ago between the university and the company specializing in the design and assembly of electrolysers should lead to the creation of a joint laboratory and a specific research program devoted to PEM electrolysis. The various players from the University of Paris-Saclay and the company will benefit from shared access to their various research and development facilities, notably at the Orsay Institute of Molecular Chemistry and Materials (ICMMO), while the university's students will take part in this collaboration by working on the various research projects. This partnership completes the research activities on green hydrogen of an ecosystem already rich in important players, such as Air Liquide, Elogen, Spark or PowiDian.



• **Fig. 14** Elogen, the French leader in PEM electrolysis, designs, manufactures and assembles its products at its site in Les Ulis.

INTERVIEW WITH ROCH DROZDOWSKI-STREHL
BRUNO CARLOTTI, MANAGING DIRECTOR OF THE INSTITUT PHOTOVOLTAÏQUE D'ILE-DE-FRANCE

The French team for new photovoltaic technology

While China dominates the European market for photovoltaic cells, is there room for a French, if not European, offer, which is more efficient? Yes, answers Roch Drozdowski-Strehl, who has been leading the Institut Photovoltaïque d'Ile-de-France (IPVF) since 2019.

What is the specificity of the Institut Photovoltaïque d'Ile-de-France (IPVF) compared with academic laboratories and industrial R&D centers working on photovoltaics?

R D-S It is to combine the two! We are used to saying that the IPVF stands on two feet: scientific and technological excellence on the one hand, and the industrial transfer of our solutions to the industry on the other. This is the dual mission entrusted to us by our founding members, who represent both the upstream part of the sector, with top-ranking academics, and the downstream part, with world leaders in the deployment of renewable energies.
If you were to walk through our building, you would come across not only IPVF staff, but also researchers and engineers from our various founding partners or from industrial companies involved in our projects, including EDF, TotalEnergies, CNRS, École polytechnique, Air Liquide, Horiba and Rober. Together, they form a veritable "French team for new photovoltaic technology" dedicated to finding innovative solutions in this field. It has a technology platform inaugurated in 2018 - one of the latest in Europe in the field of photovoltaics.

What are your ambitions for photovoltaic energy?

R D-S When discussing solar photovoltaic energy, it is good to have three numbers in mind: 7,000 - each year, the Earth receives more than 7,000 times the energy consumption of humanity from the sun.
1 terawatt - the amount of solar capacity already installed worldwide, a global threshold that was crossed during April 2022, showing rapid progress. For the record, we were only at 100 megawatts ten years ago. And this progress is expected to accelerate further as the next terawatt is expected to be passed again in just three years.
Finally, 90% - the share of renewables in the additional electricity generation capacity installed in the next five years: according to the International Energy Agency (IEA), two thirds of this 90% is photovoltaic.
This shows its predominant role in the evolution of the global energy mix. This ability to transform the photon into an electron is not only a growing market, but a global one. Europe, along with the United States and China, is one of the main markets with double-digit growth rates.

> **"1 terawatt - the amount of solar capacity already installed worldwide."**

The fact remains that Europe's share in the production of photovoltaic cells is marginal..

R D-S I was going to come to that. We can only deplore this inconsistency between a sustained demand and an almost non-existent European supply. On the one hand, the EU is displaying its ambition to be a major player in the energy transition, but on the other hand, it does not have the production capacity for an important component of renewable energy, photovoltaic panels. This raises questions about our security of supply and, more fundamentally, our sovereignty in a world where renewables will play an increasing role. Importing them on a massive scale also means depriving ourselves of the possibility of creating an industrial sector that would provide jobs in Europe. We could not remain inactive faced with this situation.

However, the ambition of the IPVF is not to reinvent the wheel, but to design new generation photovoltaic cells...

R D-S This new generation photovoltaic consists of a marriage between the silicon-based layer - the current market standard - and a new "thin-film" material (perovskite), developed at the IPVF.
The stacking of these two layers forms an assembly called a "tandem" device, which allows better yields (up to 30% instead of 23%), thanks to the greater capture of the light spectrum. Thin-film materials are a breakthrough technology, low in materials and energy, at the heart of the IPVF's technological developments.

When do you plan to move into industrial production?

R D-S As far as perovskite-based "tandem" cells are concerned, we are engaged in a maturation and technology transfer project with VOLTEC Solar, the French leader in solar energy located in the Grand Est region. From 2023, we will host a pilot line in our premises. A 200 MW production line will then be installed on the VOLTEC Solar industrial site before the construction of a giga-factory in 2025.
In this respect, we are well on our way to meeting the impact objectives of France 2030. Moreover, on the occasion of the first anniversary of this scheme, the IPVF was one of the 5 winners selected, from among 1,750, to present its achievements to date and its development prospects.

What makes you confident that the IPVF will be among the leaders in the industry? Its inclusion in the Paris-Saclay ecosystem?

R D-S Our inclusion in this ecosystem is our undeniable strength. It goes back further than we think. Although the IPVF was created in 2013, it is actually the result of the pooling of teams that had already been working here for several years on solar energy and that include world-class experts: Pere Roca i Cabarrocas, IPVF Scientific Director; Daniel Lincot, former Scientific Director; Jean-François Guillemoles, Director of the UMR IPVF, and so on.
Our strength also lies in the mission statement set by our supervisors: it sets precise targets for moving from the laboratory research stage to industrialization.
As a result, in addition to research equipment, we have adopted the methods of the industrial world, so that our advances can lead to mass production and, therefore, be more easily appropriated by industry.

"Our inclusion in the Paris-Saclay ecosystem is an undeniable strength."

What makes you different from equivalent structures in Europe - the German Fraunhofer Institutes, for example?

R D-S Other structures do indeed, like us, conduct research with academics for industrial applications. We know them well, and while we sometimes see them as competitors, we prefer to see them as potential partners. I am thinking, in addition to Fraunhofer ISE, of Imec (Belgium) and EPFL (Switzerland).
If we had to find distinctions, I would say that beyond our scientific excellence, we seek to develop maximum agility, a more "start-up" state of mind to best meet the needs of our customers: we are focused on technological innovation with the ambition of removing barriers to move as quickly as possible to an industrialization phase.

Listening to you, it would appear that you are in a logic of "coopetition". What do you say to those who consider that it is a "team of Europe" that should be formed to work on second-generation photovoltaics?

R D-S I would say they are absolutely right! Since the competition is global, it is in our interest as Europeans to join forces. That's the direction we're heading in. This is demonstrated by the "Horizon Europe" program, which encourages cooperation between European partners. At the same time, I think it is healthy to cultivate a certain degree of competition, allowing each R&D center to showcase its spearheads. That's how we'll come up with the most relevant and differentiating solutions compared with Chinese or American offers. The fact that we are pursuing our own industrial projects within the IPVF does not prevent us from seeking out skills that may be lacking across Europe, quite the opposite.

A word about the building that houses the IPVF: how does it set an example in terms of energy?

R D-S Naturally, this building had to be exemplary in terms of energy efficiency. The roof surface is designed to accommodate panels and test their effectiveness. The entire building is certified High Environmental Quality (NF HQE). This is not without its problems in terms of telecommunications, as low-power situations sometimes interfere with telephone signals! In the context of the energy crisis that we are experiencing, energy efficiency is the focus of particular attention from our operating teams. What are the impacts on the work of variations in temperature and humidity settings, for example? Our teams are working to answer this type of question, knowing that laboratories such as ours require a high level of control of the experimental environment. We must therefore characterize the precise needs, in space, by area, and over time.

Interview by Sylvain Allemand

A strong innovation dynamic

With some thirty high-tech start-ups created in the energy sector since 2010, the Paris-Saclay region is showing a stable and regular growth rate. Among the first start-ups created, now well established, are **Smart Impulse, Green Communications, Nawa Technologies, WIN MS, Adionics and Glowee**. Among the latest companies developed: **Lemon Energy, Enogrid, Datafarm, Streem** or **Wind my Roof**. These start-ups were founded on a technology developed in a Paris-Saclay laboratory, created by a founder from the cluster or located in the region. They are active in a wide range of applications, from the industrial production of silicon-based nanometric powders with **Nanomakers** and eco-friendly lithium with **Geolith** to the design of solar energy storage systems with **Airthium,** energy optimization consulting with **Hello Watt** and **Ecojoko**, and low-carbon heating and cooling solutions with **Accenta**.

This dynamism of creation is largely the result of the structuring of the energy sector in the region. Higher education institutions, fundamental research laboratories, applied research institutes, prestigious training organizations, leading companies in the sector, innovative collaborative programs, the exceptional concentration of resources and partners on the plateau makes Paris-Saclay one of the most attractive innovation clusters for investors, innovators and entrepreneurs from around the world.

These start-ups have also been able to benefit from the many places dedicated to innovation and the creation of innovative companies within Paris-Saclay. Incubators are run by the schools in the region: the **X-UP incubator, Pépinière X-Tech** at École polytechnique, the **503 Entrepreneurship and Innovation Center** at the Institut d'Optique, and the **CentraleSupélec incubator.** Accelerators and incubators emanate from public or private structures: **IncubAlliance, WILCO, Paris-Saclay TTO (SATT)**. Ilabs and fablabs are also dedicated to the development of innovative technologies.

30

HIGH-TECH START-UPS CREATED IN THE ENERGY SECTOR SINCE 2010

Start-ups benefit from numerous places dedicated to innovation and the creation of innovative companies within Paris-Saclay.

Adionics revolutionizes the global lithium mining market

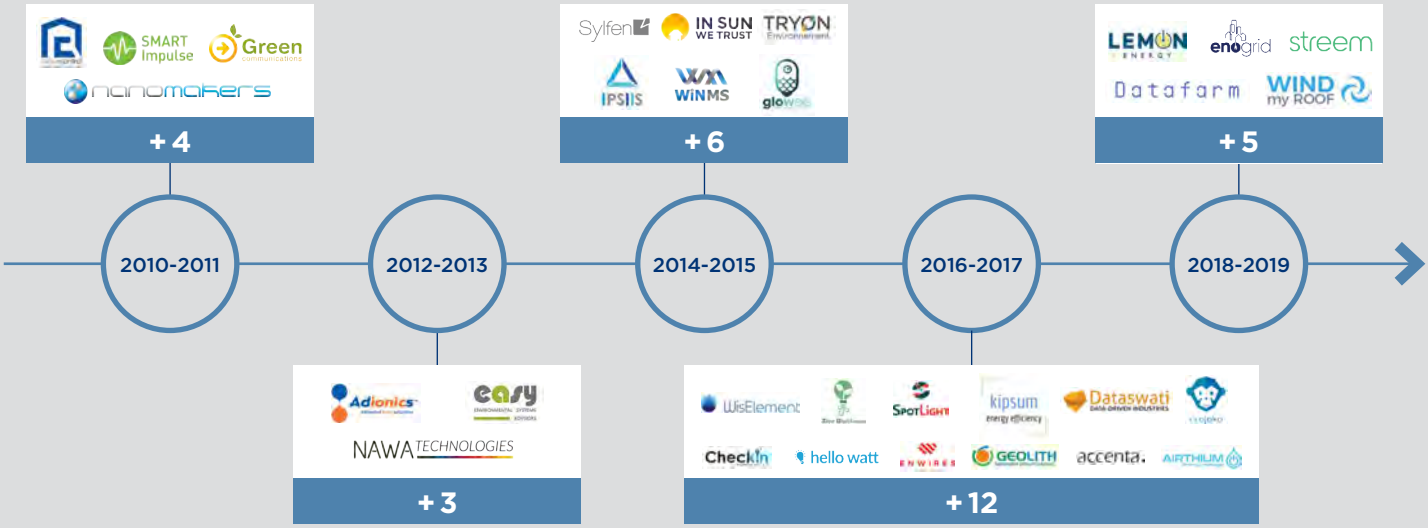
Founded in 2012 and incubated within Incuballiance, Adionics specializes in seawater desalination. The originator of a process for the selective extraction of salts from aqueous effluents by liquid means at ambient temperature, called AquaOmnes, Adionics is offering its solution *via* two pilot projects installed in Masdar in the United Arab Emirates and in Martigues on an EDF site. The start-up is now focusing on adapting its technology to the extraction of lithium, which is essential for the manufacture of batteries, a rapidly expanding market.

Its latest round of financing of €7 million in 2021, notably from the PSIM Fund operated by Bpifrance, will enable it to set up its first industrial "Clean Lithium" production unit in the heart of the South American "Lithium Triangle". It will also enable the company to launch the commercialization of its solution, a disruptive technology without equivalent worldwide that could revolutionize the lithium extraction market for the benefit of greener energy and mobility.

• **Fig. 15** Lithium extraction site.

Start-ups in the region

For the past ten years, the pace and number of start-up creations in the Paris-Saclay region has been stable and regular. This illustrates the cluster's dynamic innovation in the field of energy transition.



Glowee invents public lighting based on marine bioluminescence

A particularly innovative start-up that is emblematic of the cluster, Glowee has been based at the Genopole located in Evry-Courcouronnes since 2014.
Its particularly original innovation consists in developing biological light. Glowee relies on bioluminescence, the light produced and diffused by certain living organisms such as fireflies or glow worms, but also by more than 80% of marine organisms.
On this basis, Glowee develops a living raw material made of marine bacteria that are naturally bioluminescent and easily cultivated in the laboratory and develops products adapted to the integration of this liquid and biological light. With its Glowpolis offer, the start-up intends to revolutionize public lighting with a range of street furniture based on marine bioluminescence.
A first experiment, in this context, began in the heart of the city of Rambouillet in January 2023 with the first bioluminescent street furniture for its cultural center La Lanterne. With €1.7 million in funding from the European Commission as part of a call for projects on energy transition won in 2020, Glowee offers a sustainable alternative to artificial light.
The passage to scale is planned for 2024 with lots of street furniture allowing a whole district to be lit.
An innovative project for the city of tomorrow.

Lemon Energy decarbonizes the industry

Stemming from the Paris-Saclay ecosystem, a member of the French Tech Paris-Saclay and located in the Paris-Saclay Playground, Lemon Energy is representative of the region's start-ups.
The start-up, which is dedicated to industry, assists its clients in implementing low-carbon strategies to optimize the energy performance of their sites and make decarbonization a real competitive lever. The start-up offers a range of services and expertise for all types of industries.
Its innovation, recognized by the Ministry of Higher Education and Research, is based on Industry 4.0 technologies, in particular predictive analysis algorithms adapted to processes, to improve the energy performance of sites in real time. Over the past four years, the company has detected energy savings equivalent to the annual consumption of a city of 620,000 inhabitants.

INTERVIEW WITH DIDIER ROUX
CO-FOUNDER AND CEO OF WATTANYWHERE

WattAnyWhere, a nugget of the Paris-Saclay ecosystem at the heart of energy issues

Converting renewable ethanol into clean electricity to serve the fast-charging needs of electric vehicles in Europe, through an innovation in the form of a fuel cell generator. This is the ambition of the start-up WattAnyWhere, winner of the 2022 SPRING 50 in the mobility category. Its co-founder, Didier Roux, tells us more, including the stakes at European level.

WattAnyWhere aims to provide energy from biomass for fast charging of electric vehicles. How did you come to this solution?

DR The European Union has set an ambitious target for fast electric charging (25 terawatt-hours by 2030) to ensure the transition from combustion engine vehicles to electric vehicles. However, this deployment assumes that the entire European territory will be covered at an average rate of one terminal every 60 km - an average defined by the European Commission. And yet, according to the players involved in this deployment, whom my associate Alex Laybros and I took the time to meet, connecting fast charging stations will take time - between one and two years in Western Europe, and between two and three years in Eastern Europe. In reality, it is not enough to install charging stations, the electrical network must also be adapted. It was simply not designed to power fast charging stations that require a power level of between 50 and 350 kW depending on the vehicle, that is to say in the order of one megawatt to be provided with just five stations... Not only that, but the charging stations cannot always be installed as close as possible to the power lines, so additional cables have to be run through land that does not belong to the power provider or the charging station operator. The result is the risk of longer delays due to administrative procedures. In addition to being time-consuming, the deployment will be expensive - it will cost nearly 500,000 euros per station.

What does your solution involve?

DR It consists of an innovative generator, able to provide 350 kW of power at a competitive price, and which we guarantee is quiet, non-polluting and carbon-neutral. Unlike conventional diesel-powered generators, ours uses ethanol and fuel cells.

"We guarantee an innovative, quiet, non-polluting, carbon-neutral generator set that can deliver 350 kW of power at a competitive price."

Why this double bias? First, ethanol: it has the advantage of being a renewable fuel, produced in large quantities by the cereal and sugar industries, to the tune of 10 billion liters per year in Europe and 120 billion worldwide. Currently, 80% of European production is blended with gasoline for our internal combustion engines, which are set to disappear by 2030 in Europe, to the benefit of electric vehicles, sales of which are now growing rapidly. With our solution, ethanol can be allocated to other uses by being converted into electricity with, in addition, greater efficiency - up to 60%, twice that of a combustion engine.
Our solution is all the more ecological since ethanol already comes from the reuse of residues and leftovers from the production of wheat and sugar. The 10 billion liters available in France will also make it possible to produce 36 terawatt-hours, the equivalent of the annual production of four nuclear reactors.

How did you come to bring together biomass and electric recharging, two worlds that are not usually associated?

DR Personally, in parallel to my professional activity, I have long been interested in the challenges of the ecological transition, which has led me to focus my attention on various solutions, particularly in the energy field. This is how I came to be interested in ethanol which, being a by-product of sugar production, offers the advantage of not competing with food production.

Giving up this option would also put cereal or beet producers in difficulty, as they would be deprived of an outlet.
Ethanol has other virtues in terms of its use: due to its molecular composition, it can be considered as liquid hydrogen. Thanks to the reformer that we have combined with a solid oxide fuel cell (SOFC), we are able to convert ethanol into hydrogen very efficiently. This allows us to take advantage of the very good energy density of ethanol (5.83 kWh/l compared with 1.56 kWh/l of hydrogen compressed to 700 bars).
In short, our solution is in line with history. Especially since we are only using technologies that are used elsewhere to produce green hydrogen. We are not starting from a blank page.

What are the skills and expertise that you mobilize between yours and your partner's?

DR Alex Laybros and I are both graduates of the École Nationale Supérieure de l'Électronique et de ses Applications (ENSEA).
To validate our initial hypothesis and ensure that it could be implemented, we visited trade shows, approached ePURE, the European ethanol producers' union, and contacted research engineers at ENSEA (to work on the power electronics of our system), INRAe (to deepen our knowledge of sugar beets and the prospects for ethanol production in France) and EPFL, where one of the laboratories had already explored the possibility of feeding an SOFC with methane gas.

What is your current status?

DR We have run a first demonstrator in the laboratory with 350 Watts of power. We are, of course, still far from the 350 kW promise, but we plan to work next year on a second 10 kW demonstrator, which we will deliver to a first customer for testing under real conditions to verify that our system can be installed in the city, connected to recharging stations and provide electricity. The next step will be to develop a 50 kW module that we will then duplicate to reach the 350 kW target.

How do you plan to finance these different stages of demonstration and testing?

DR For the needs of the first demonstrator, we solicited people from our entourage - "Family, Friends, Fools" in start-up jargon - who contributed with tickets ranging from 5,000 to 50,000 euros. This allowed us to apply for grants and loans. Thanks to this first demonstrator, we will be in a position, during 2023, to finalize a €6 million financing round to build the second demonstrator and launch the developments for the third.

What about the price of a refill with your process?

DR To date, we are able to be competitive with the price of electricity from the grid. The reason for this is simple: in order to meet sudden changes in demand, a supplier is reduced to sourcing on the Spot market*, which is based on instantaneous negotiations of the price per kilowatt-hour. However, this could be as high as 6 euros per kilowatt hour, compared with the average cost of 20 cents per kW guaranteed by your subscription. In other words, the pricing solutions offered by grid-dependent suppliers could be unaffordable for many drivers in tight electricity market situations such as we are experiencing today and will continue to experience in the future.
The risk is lower for ethanol-based electricity because the price of ethanol is negotiated under annual contracts, which allows for electricity to be supplied at a constant price throughout the year.

> **"We want to stay in the Paris-Saclay ecosystem because, to ensure our development, we will need skills in electronics and software."**

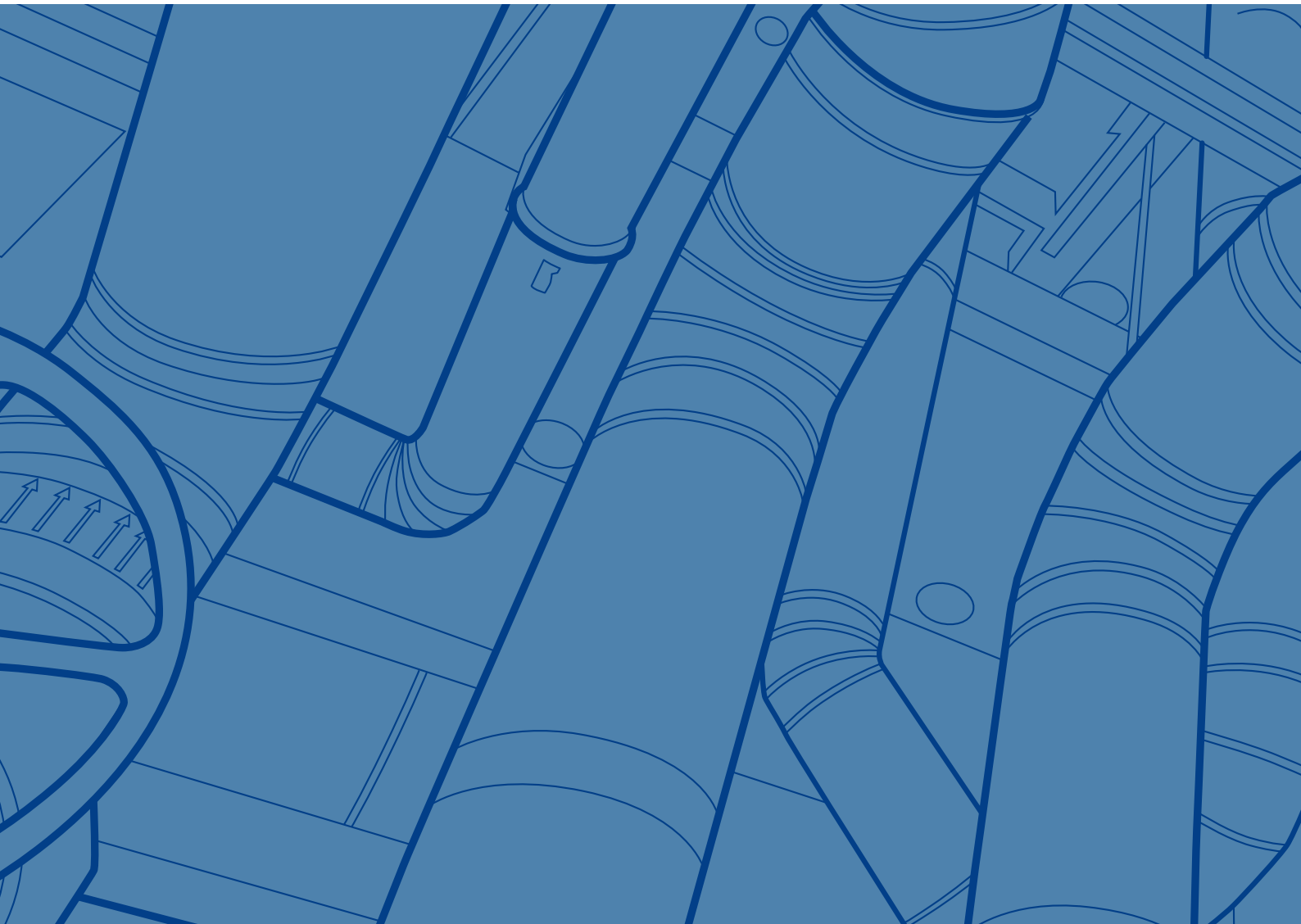
To what extent is your project indebted to the Paris-Saclay ecosystem?

DR In addition to the SPRING 50 award we won in the "Mobility" category, we were incubated within IncubAlliance, which helped us a lot when we started WattAnyWhere. in the future, we want to stay in the ecosystem because, to ensure our development, we will need skills in electronics and software.
And in this respect, Paris-Saclay is a unique breeding ground in Europe because of the presence of leading engineering schools, industrialists, and other players who set the standard in these fields.

Interview by Sylvain Allemand

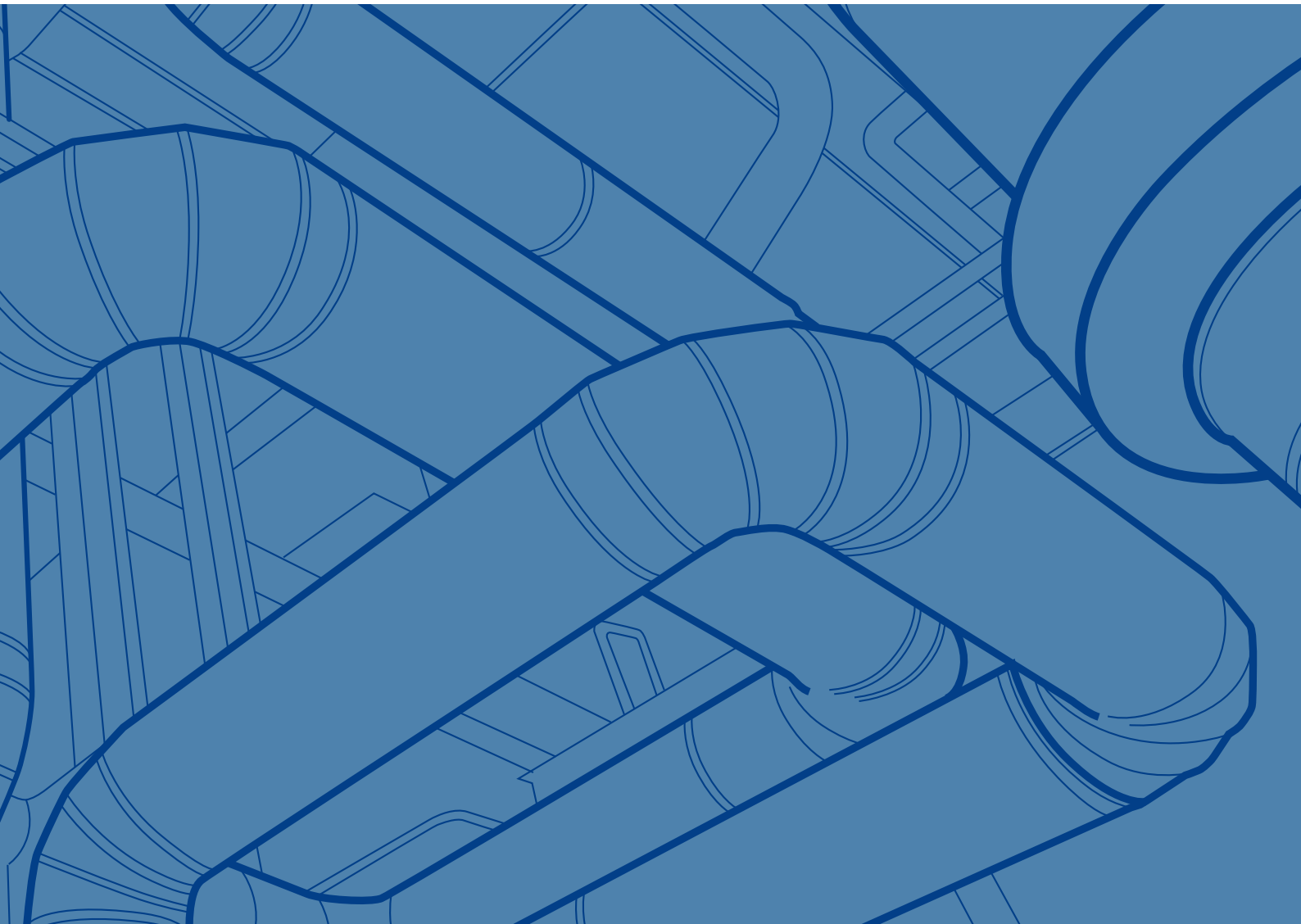
*A market in which commodities are sold for cash and delivered promptly when the transaction is settled, and other non-financial markets, such as futures markets for commodities (according to the Energy Regulatory Commission).

A region of experimentation and innovation



Combining scientific, economic development and sustainable development ambitions, the Paris-Saclay science and technology cluster is a major component of the Greater Paris project, which aims to consolidate the position of the Île-de-France region and of France among the world's leading innovation hubs.

This region is also a great opportunity to implement a new energy model that fully meets the objectives of the Pluriannual Energy Program as well as those of the National Low-Carbon Strategy, and contributes to the commitments made by France in the Paris Climate Agreement adopted at COP21. The strong presence of the energy sector in the region is combined with a strong desire to make Paris-Saclay a positive energy eco-region, an open-air demonstrator of the energy transition and a laboratory for the city of tomorrow.



A laboratory for the energy transition

The Paris-Saclay region is both a laboratory for the city of the future and a demonstrator of the energy transition. In order to respond to the social and environmental concerns that guide the project, the Paris-Saclay Public Development Authority (EPA Paris-Saclay) has voluntarily committed itself to a **corporate social responsibility (CSR)** approach. Its ambition: social and territorial cohesion and **environmental excellence**.

As part of its development, EPA Paris-Saclay is designing mixed, compact, sustainable neighborhoods with shared uses that meet the social, energy and ecological challenges of tomorrow. More specifically, in the area of energy, the ambition is to make Paris-Saclay a **positive energy region**, using local and renewable energies on a large scale and building in a way that promotes energy sobriety. The development is based on **low-carbon impact buildings,** wood structures, green spaces, reversible buildings and the rehabilitation of existing buildings. 30% of the roofs are reserved for **photovoltaic equipment** and all the buildings are *PV-Ready* (photovoltaic *ready*)in order to facilitate the installation of photovoltaic panels once the buildings are delivered. As for the **Paris-Saclay heat and cold exchange network**, which is largely powered by geothermal energy, it constitutes, along with a smart grid, the Paris-Saclay intelligent multi-energy network, a world first on this scale.

The city of tomorrow also relies on **innovative mobility solutions**. In the Paris-Saclay area, autonomous shuttles are being tested, as well as a service that allows users to see the available spaces in the various existing parking facilities. Numerous spaces are dedicated to electric vehicles in the public space and hundreds of bicycles are available for self-service.

• **Fig. 16** Soft modes and public transport.

A heat and cold exchange network unique in France

1RE INFRASTRUCTURE OF HEAT AND COLD EXCHANGE OF URBAN SCALE IN FRANCE

The Paris-Saclay heat and cold exchange network, the first fifth-generation energy network in France and one of the five European demonstrators, is an essential infrastructure that makes it possible to exchange energy between different real estate projects, contributing to a reduction in the cost of final energy and halving CO_2 emissions.
The Paris-Saclay urban campus has particularly favorable conditions for this experiment: a set of coordinated development operations allowing for complementarity and mutualization between the heating and cooling needs of the various institutions, large scientific structures releasing reusable heat in a circular economy and access to a local and perennial geothermal resource, the Albien aquifer. The latter is an underground water table drawn from a depth of 700 m, whose reserves are estimated at 700 billion m^3 at an average temperature of 30°C. The network irrigates the entire urban campus and supplies the buildings through exchange substations. It also feeds heat pumps which, in addition to the heat provided by geothermal energy, produce the cold required for air conditioning. All the thermal installations are managed in a coordinated manner and are controlled in real time *using* digital technologies to optimize energy distribution according to the various uses and characteristics of the buildings, but also according to the cost of energy and their carbon intensity. For example, after 6 p.m., the heating of unoccupied or empty commercial and educational buildings decreases, while that of homes increases. In the future, other sources of renewable energy and recovery (RE&R) could supply the network such as a methanization unit or a biomass heating plant, the heating and cooling network constituting a structuring and evolving framework.
With 25 km of network running under public roads, 2,146 million m^2 of connected surfaces representing 50 MW of cumulative heating and cooling capacity, and supplied with 50% renewable energy, this network is the first urban-scale heat and cold exchange infrastructure in France.

25 KM OF NETWORK

50 MW OF POWER

50 % OF RENEWABLE ENERGY SUPPLY

• **Fig. 17** The heating and cooling network of the Urban Campus in the construction phase.

EPA Paris-Saclay is thus part of a sustainable development strategy in line with national objectives. This ambition has been recognized by the State with the labeling of the Paris-Saclay urban campus as a **"Positive Energy Region for Green Growth"**. It is fully in line with the framework defined by the Ministry of Ecological Transition for the "Habiter la France de demain" program: preparing cities and regions that are sober, resilient, inclusive and productive.

A sustainable development strategy focused on environmental excellence

The values of environmental and social exemplarity have been central to the Paris-Saclay territorial project since its launch.
The Sustainable Development and Social Responsibility strategy finalized in 2022 and validated by all local elected officials reaffirms these exemplary values.
Its ambition is to develop a sober, resilient, inclusive and productive region and is based on three strategic objectives:
• Environmental excellence for a pleasant living environment within a low-carbon region, adapted to climate change and giving a strong place to nature and agriculture.
• Social and territorial cohesion with a place for everyone in the new districts and a sharing of the educational and economic dynamics of the Paris-Saclay project with the entire region.
• A participatory and inclusive approach that reinforces the logic of co-construction in the design and implementation of the project.
Developed with all of the region's stakeholders, this strategy is broken down into some forty actions to be implemented or initiated between 2022 and 2027. In terms of energy, EPA Paris-Saclay is focusing on sobriety in order to meet the major climatic and environmental challenges and to contribute to national and international trajectories and commitments.
In particular, it is a matter of building low-energy and low-carbon neighborhoods (buildings and public spaces), developing renewable energies, ensuring the peaceful coexistence of new activities with agricultural and natural areas, and developing peaceful and low-carbon mobility.
Key actions include:
• Encourage the development of real estate projects that contribute to carbon neutrality within the neighborhoods developed by EPA Paris-Saclay and revise the requirements to guarantee a high level of environmental quality for real estate projects, mobilize the bio-sourced materials sector (wood, straw, hemp, etc.) and implement the commitments of the Fibois Pact with 40% of the surface area in wood construction.
• Support and facilitate the development of renewable energy in new neighborhoods and within the region, and continue the development of the urban campus renewable heat and cold exchange network and rooftop photovoltaics.
• Deploy a network of safe roads and the facilities necessary for the development of active mobility (cycling, walking, etc.).
• Strengthen the public transport offer on axes complementary to line 18 of the Grand Paris Express and around multimodal hubs.

The ambition is to make Paris-Saclay a positive energy region, using local and renewable energies on a large scale.

• **Fig. 18** The northern edge of the École polytechnique district and its basins.

INTERVIEW WITH GREGORY CHOPPINET
FOUNDER AND PRESIDENT OF THE START-UP LEMON ENERGY

Lemon Energy, an emblematic start-up of the Paris-Saclay ecosystem

Improving the energy efficiency of industrial processes, based on a diagnosis and the implementation of customized solutions, such is the vocation of this young innovative company housed at the Playground, the Incubator Incubator Business Centre of Paris-Saclay. Details from its co-founder.

Could just start by telling us a bit about Lemon Energy?

GC Lemon Energy is an industrial energy efficiency consultancy, which works on the principle that the cheapest energy is the one we do not consume. Hence the emphasis on improving the energy efficiency of processes. We mainly target industrialists in the food, chemical, steel, plastics and glass industries. We offer them long-term support, starting with a global energy assessment of their production systems' consumption, in order to define a low-carbon strategy. Finally, we can follow up on the actions implemented, based on the data collected by means of sensors, and thus verify that the objectives are actually achieved. The goal is not necessarily to produce less, and even less quality, but better, with less energy.

> **"We offer long-term support, from the overall energy assessment to monitoring and the definition of a low-carbon strategy."**

You not only evaluate the amount of investment required, but also identify the sources of financing and subsidies to which the manufacturer is entitled

GC That's right. We work closely with ADEME, Bpifrance and local authorities, particularly the regions, to ensure that our customers benefit from the financing they are entitled to for energy transition, but also for innovation. After all, our interventions offer the chance to develop innovative processes with the constant concern of not harming the quality of the products.

How do you achieve this?

GC By working hand in hand with the engineering teams of the manufacturers to evaluate the energy impact of the different options that are available on the quality of the processes. Even if it means convincing them to question their professional practices and routines. Hence the need to establish a relationship of trust. Especially since engineers involved in industrial processes may have a culture of secrecy or confidentiality, which does not incline them to collaborate with outside parties, even if they are engineers like themselves.

How do you manage to establish this relationship of trust?

GC Our design office is independent; it is not backed by any industrial group that could be a competitor. And we are still small enough to establish close relationships with our customers. Long-term support has only gradually become necessary.
In the beginning, our core business was the feasibility study of our clients' improvement projects. From now on, we will go as far as to ensure the follow-up of the performances over several years and to encourage the team to reach an objective of reducing energy consumption. A plus which obviously corresponded to a real expectation and which contributed to establishing this relationship of trust that I mentioned. We have been helped in this by our partners (ADEME, Bpifrance) who have helped finance innovative and ambitious projects.

You present yourself as a design office. However, you talk more about a start-up approach...

GC In fact, we have been awarded the "Young Innovative Company" label for the analysis of energy data. We have equipped ourselves with R&D resources in order to offer algorithms that can model the energy behavior of industrial process equipment as accurately as possible. We thus make tailor-made recommendations that are as adapted as possible to our clients' uses and to their requirements in terms of production quality.

A tailor-made and long-term support, you say. What business model have you defined to achieve this?

GC At the beginning, as I said, our activity was focused on fixed-price studies. This year, in response to the expansion of our activity to long-term monitoring, we started offering a subscription formula, which includes the provision of a leading expert, the installation of analysis software allowing the customer to interact with him, to monitor the consumption of such or such equipment.

Where are you in terms of staffing? What are your development ambitions?

GC Lemon Energy currently employs about 20 people. We plan to reach 30 by 2024 with a forecast of 40 by 2026.

What profiles and skills do these staff members have?

GC Currently, half of them are engineers, with various profiles: chemist, process engineer, thermodynamics specialist, electrician, AI [Artificial Intelligence] IT [Information Technology] and in UX design to improve the ergonomics of our dashboard interfaces.
In addition, there are project managers, sales representatives, product marketing managers and management managers. Currently, we are strengthening our R&D by recruiting post-doctoral engineers - until now, each of our engineers spent part of their time on R&D.

What is your profile?

GC My background is as an engineer in production systems management. Before creating Lemon Energy, I worked in the automotive sector, at Renault, in logistics; I was already dealing with energy supply optimization issues. In 2008, I made the choice of a professional conversion. I did a specialized master's degree at CentraleSupélec on the new energy markets, which trained both in marketing and sales and in the technical aspects of energy. Then, in 2010, I joined the marketing department of EDF, where I stayed for four years, then I joined a research laboratory: the Paris-Saclay Energy Efficiency Institute (PS2E), which aims to pool energy performance analyses of industrial sites. This experience is not unrelated to the creation of my company. I created it with one of my colleagues from this institute.

> **"I am more than ever committed to remaining in the Paris-Saclay ecosystem, where we find all the major players in the field, in a close relationship."**

CentraleSupélec, EDF, PS2E Institute...
You could say that Lemon Energy is a "child" of the Paris-Saclay ecosystem, especially since you are currently housed in the Playground.

GC Completely! I would like to add that before joining this Incubator, we started out in the CentraleSupélec incubator. I am more than ever committed to remaining in this ecosystem to which we are indebted, and because we find there all the major players in the field, in a relationship of proximity: EDF Lab, whose campus I can see from our offices; TotalEnergies, whose teams are on the floor above. Not to mention all the higher education and research establishments located within a few hundred meters, including the CentraleSupélec school, with which we continue to collaborate. In short, it is an environment rich in opportunities, stimulating and to which we are attached.

Interview by Sylvain Allemand

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