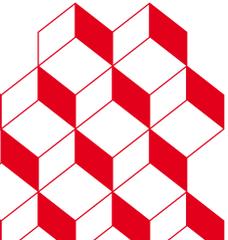




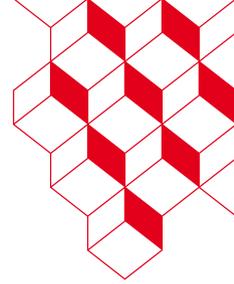
iresne



*REsearch Institute
on Nuclear Systems
for a Low Carbon Energy Production*



POWERING THE NUCLEAR SYSTEMS RESEARCH



“ The **IRESNE** institute, located on the **CEA Cadarache** site, is a result of the **CEA's** desire to promote *strong and dynamic R&D* in the field of nuclear fission, by bringing together the three historical components of research in this field:
studies on reactors, fuels, and nuclear systems and technologies.

Its name is a reference to **Irène JOLIOT-CURIE**, the international figure in nuclear research and winner of the Nobel Prize in Chemistry in 1935 for the discovery of induced radioactivity with her husband **Frédéric JOLIOT-CURIE**.

The **IRESNE** research activities target a *low-carbon energy mix*, with the aim of meeting the challenges of combating global warming and ensuring France's energy sovereignty. ”

In this brochure, find out more about our institute, our research and our activities to develop an integrated, decarbonised energy system.

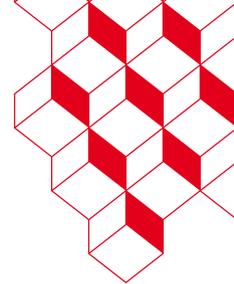
Jean-Michel Ruggieri,
Director of IRESNE.



IRESNE managers in front of the JHR.



LECA-STAR.
Hot laboratory dedicated
to R&D on irradiated fuels.
© A. Aubert/CEA



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WHO ARE WE?

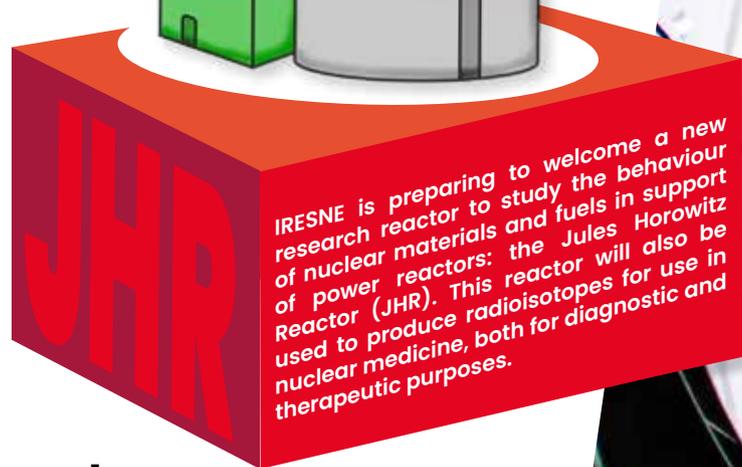
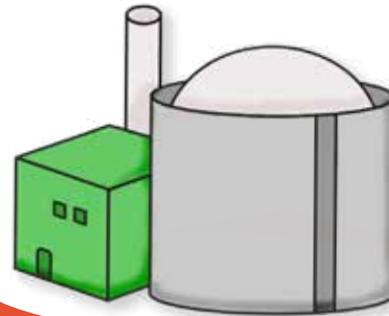
The Research Institute for Nuclear Systems for Low-Carbon Energy Production (IRESNE) was created on **1 February 2020** by the **CEA**. It brings together in a single unit all the research laboratories studying nuclear

fission within the **three R&D departments** for *reactors, fuels and nuclear technologies*. Nuclear power is a major component of France's low-carbon energy mix, because of its availability and its ability to adapt to demand.

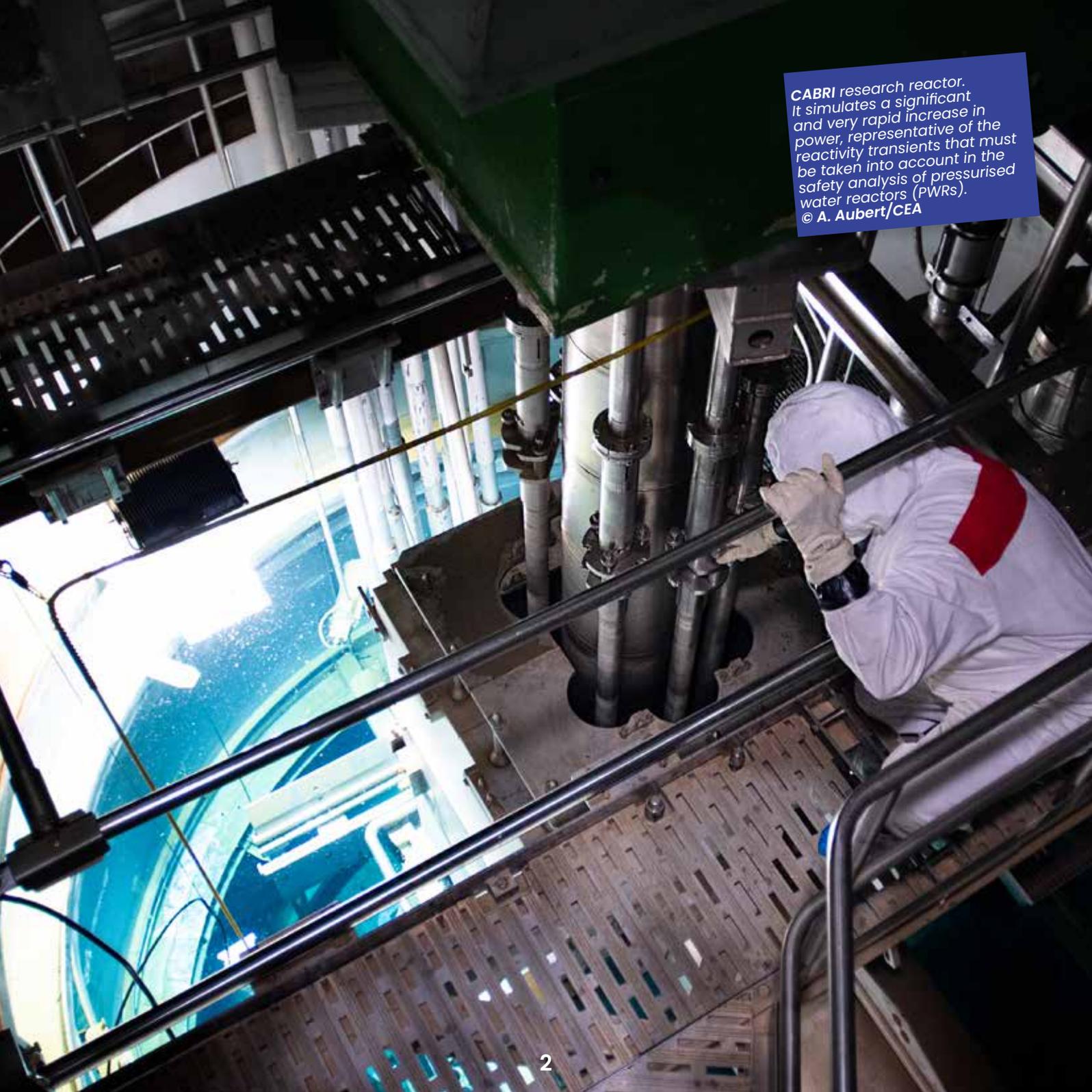
The **IRESNE teams** are responsible for *testing, qualifying and simulating* nuclear reactor components, using a remarkable **"FISSION"** experimental platform. They design and innovate for the current and future nuclear industry, in particular to support their industrial partners such as **EDF** and **FRAMATOME**, by studying new types of reactors, components and fuels.

For example: *small modular reactors, fast-neutron reactors and molten-salt reactors.*

IRESNE's internationally recognized "FISSION" experimental platform includes additional state-of-the-art facilities in the field, including a "hot" laboratory and a research reactor for nuclear safety studies. The studies carried out on the experimental platform are combined with a strategic *modelling/simulation/digital twin* approach to optimise and interpret the experiments and account for the multi-physical and multi-scale phenomena governing the operation of **nuclear reactors**.



IRESNE is preparing to welcome a new research reactor to study the behaviour of nuclear materials and fuels in support of power reactors: the Jules Horowitz Reactor (JHR). This reactor will also be used to produce radioisotopes for use in nuclear medicine, both for diagnostic and therapeutic purposes.

A high-angle photograph of a person in a white protective suit and gloves working on a complex industrial reactor system. The person is positioned on a metal grating platform, leaning over several vertical pipes and components. The background shows a large, circular structure with a blueish tint, possibly a containment vessel or a large tank. The scene is dimly lit, with some bright light coming from the left side. A blue text box is overlaid in the top right corner.

CABRI research reactor.
It simulates a significant
and very rapid increase in
power, representative of the
reactivity transients that must
be taken into account in the
safety analysis of pressurised
water reactors (PWRs).
© A. Aubert/CEA



POSEIDON platform.
Thermal-hydraulic and
hydromechanical studies
of nuclear technology
components.
© A. Aubert/CEA

OUR KEY FIGURES

1000
Employees

600 Engineers and researchers

180 Technicians

120 Doctoral and post-doctoral students

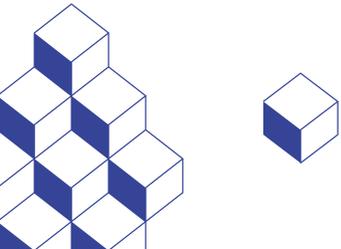
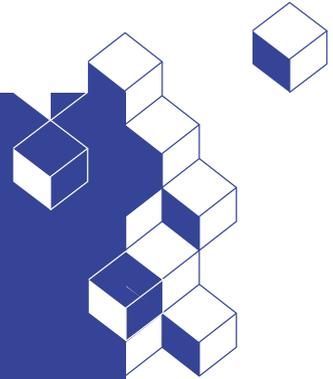
100 Trainees and work-study students

40 R&D projects

60 International partners

300 Scientific publications/year

220 Active patent families



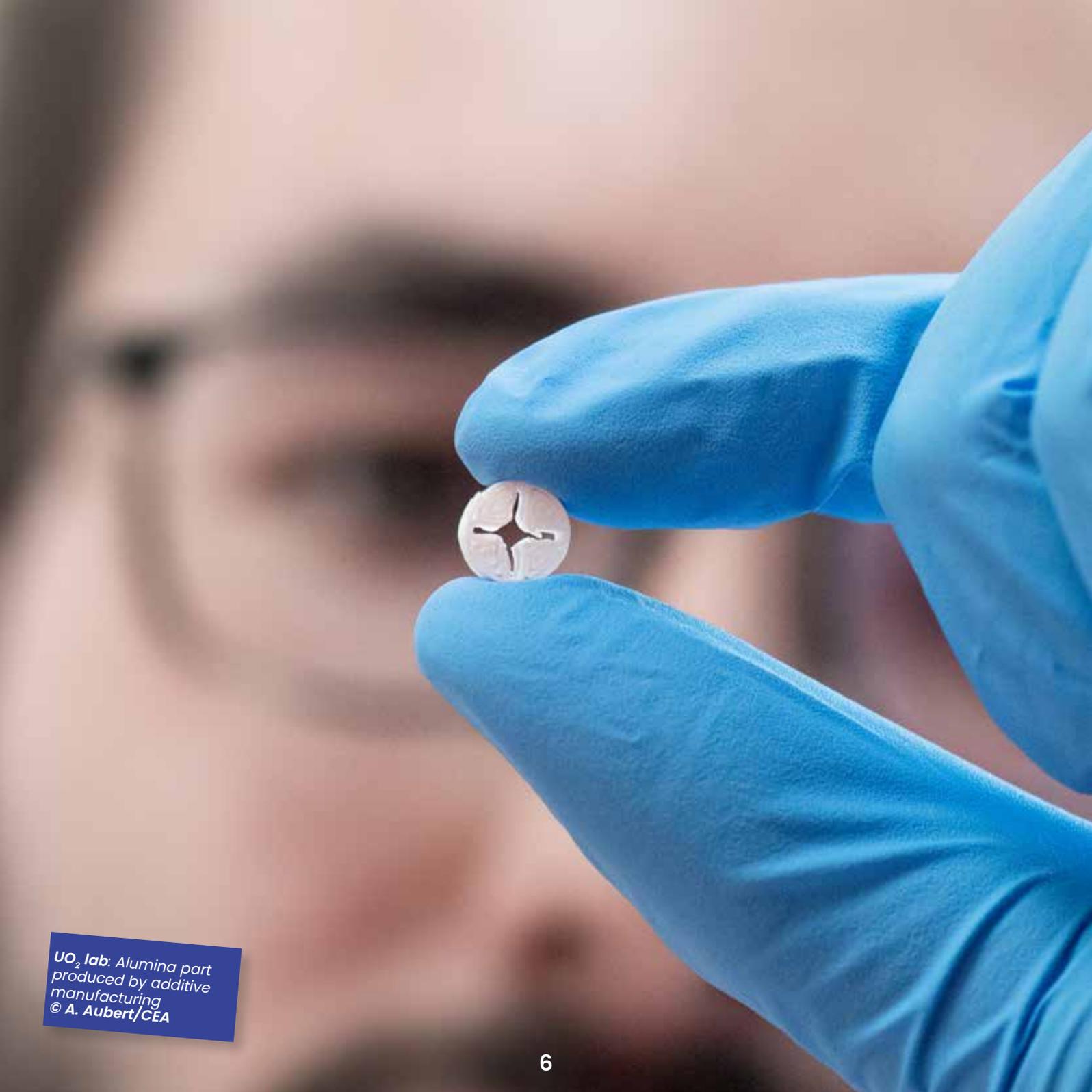
OUR MISSIONS AND OBJECTIVES

IREsNE's actions are focused around **three main missions**.

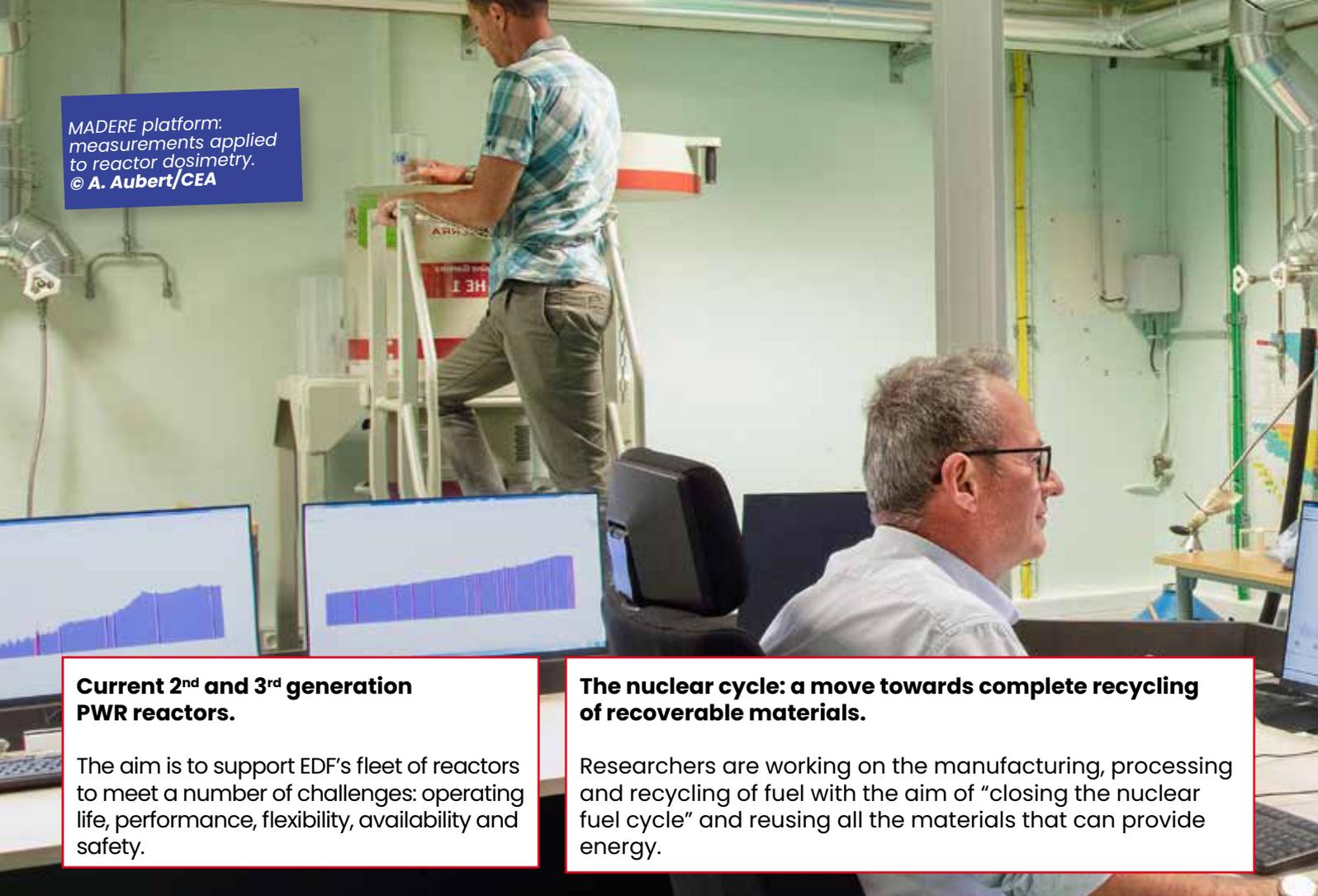
- 1. Supporting the nuclear industry:** expertise in reactors, the fuel cycle, waste management, decommissioning and marine nuclear propulsion.
- 2. Innovating for nuclear systems:** developing 3rd and 4th generation reactors and associated technologies, such as small modular reactors, fast-neutron reactors, molten-salt reactors and sodium-cooled reactors.
- 3. Integrating nuclear power into a low-carbon energy mix:** promoting the energy transition by producing heat and hydrogen from reactors and innovative energy conversion systems.

These missions meet **four strategic objectives**.

- 4. Integrated energy system:** analysing the technological, economic, societal and environmental dimensions of nuclear power.
- 5. Energy transition:** positioning nuclear production as a pillar, by meeting current needs and optimising fuel recycling and waste treatment.
- 6. Strengthening skills:** maintaining and developing expertise for the current fleet reactors and for responsible decommissioning and waste management.
- 7. State-of-the-art infrastructures:** ensuring performance and safety control throughout the reactor life cycle, from design to decommissioning.



*UO₂ lab: Alumina part
produced by additive
manufacturing
© A. Aubert/CEA*



MADERE platform:
measurements applied
to reactor dosimetry.
© A. Aubert/CEA

Current 2nd and 3rd generation PWR reactors.

The aim is to support EDF's fleet of reactors to meet a number of challenges: operating life, performance, flexibility, availability and safety.

The nuclear cycle: a move towards complete recycling of recoverable materials.

Researchers are working on the manufacturing, processing and recycling of fuel with the aim of "closing the nuclear fuel cycle" and reusing all the materials that can provide energy.

4th generation reactors.

Research into 4th generation reactors aims to offer solutions in terms of closing the fuel cycle and using uranium resources. For example, sodium-cooled fast-neutron reactors (SFR), molten-salt reactors (MSR) and high-temperature reactors (HTR) are being studied.

The small modular reactors of the future: SMR and AMR.

Small reactors meet a specific need for energy production, not only electrical but also thermal. They can also be used to produce hydrogen. Small Modular Reactors (SMRs) use the same technology as 2nd and 3rd generation reactors such as Pressurised Water Reactors (PWRs). Advanced Modular Reactors (AMR) are based on 4th generation reactor technologies.



R&D for dismantling and decommissioning.

IRESNE also works in collaboration with other CEA units on the decommissioning of end-of-life nuclear facilities and the treatment of nuclear waste, by developing innovative processes and analysis methods.

Support for national defence.

The institute's teams contribute to research into the fuels, components and cores of the boilers used on French Navy vessels (nuclear propulsion reactors).

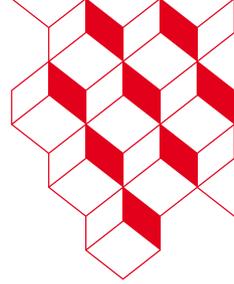
Jules Horowitz research reactor: JHR.

IRESNE is preparing to operate the Jules Horowitz research Reactor currently under construction at Cadarache, as well as carrying out the irradiation experiments that will be conducted inside this modern, high-performance facility will be an essential tool for supporting research on power reactor fuels and materials.

OUR AREAS OF RESEARCH



UO₂ lab: loading a furnace to sinter nuclear fuel pellets.
© A. Aubert/CEA



OUR R&D ACTIVITIES

To carry out its R&D missions, IRESNE relies on four cross-disciplinary areas of activity:

1 Design and innovation

The engineering teams are working on the design of reactors and technological components to support the current and future fleet. This design covers several fields, including reactor physics, thermal-hydraulics, neutronics, mechanics, fuel and process engineering.

2 Experiments

The institute's experimental "fission" platform is essential for testing and developing nuclear components and systems to meet the challenges of the energy transition. It comprises fourteen complementary R&D facilities, including a nuclear safety research reactor, technological platforms and laboratories that are unique in the world. These experiments are used to validate calculation codes and model nuclear systems.



Flow modelling study in
a heat exchanger for a
3rd generation reactor
© A. Aubert/CEA



3

Instrumentation and measurement

Instrumentation and measurement in the nuclear environment require specialist tools, adapted to conditions that are often extreme. These instruments are used to detect, measure and analyse the behaviour of nuclear components and the characteristics of nuclear reactions, such as neutron flux. Expertise in instrumentation and measurement can reduce uncertainties in the knowledge of the physical parameters that are essential for modelling.

4

Modelling and simulation

Researchers at the institute are constantly developing and improving scientific calculation tools to simulate fuel and reactor performance, and to study hypothetical accident situations such as severe accidents with core meltdown. These tools help to better understand and optimise nuclear systems.

THE EXPERIMENTAL PLATFORM

A platform located entirely on the CEA Cadarache site to study all the areas of interest in nuclear energy.



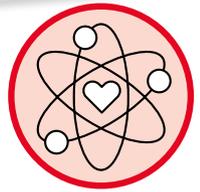
- **ATHENA:** control of contamination in reactors and the chemistry of coolants and tritium.
- **CABRI:** research reactor for irradiation and power transients of up to 20 GW.
- **Manufacture of fission chambers:** design workshop for “custom” fission chambers with 12 different geometries for measuring neutron fluxes in reactors.
- **UO₂ lab:** development and characterisation of fuels. Manufacturing processes for nuclear ceramics and powders. Measurement of the properties of these materials.
- **LARC:** radiological analyses, mineral and organic chemical analyses and elemental and isotopic analyses of traces and ultra-traces.
- **LECA-STAR:** examination of irradiated active fuels, from metre to nanometre, and manufacture of instrumented fuel rods.
- **LMN:** a laboratory specialising in non-destructive nuclear measurements, the CEA’s “nuclear measurements” centre of excellence.
- **MADERE:** measurements applied to reactor dosimetry. Measurement of the radioactive mass activity of solid samples emitting gamma or X-ray photon radiation.
- **PAPIRUS:** study of advanced liquid metal coolants, in particular sodium and molten salts, and design and qualification of instrumentation in extreme environments.
- **PLINIUS:** study of severe accidents with core meltdown. Manufacture of representative prototypical corium and chemical physics under extreme conditions.
- **POSEIDON:** thermal-hydraulic and hydromechanical studies of certain nuclear reactor components under normal, incidental or accidental conditions.
- **JHR:** Jules Horowitz Reactor for irradiation tests and the production of artificial radioelements, particularly for medical use.
- **TOTEM:** qualification of devices and equipment under reactor conditions and non-destructive nuclear measurements.

CROSS-FUNCTIONAL RESOURCES

Evaluation of basic data

Support R&D

Neutronic



Critical model

Chemical physics

Basic properties



PLINIUS
UO₂ LAB
LECA-STAR

Measurement instrumentation



TOTEM
MADERE
LMN
FISSION CHAMBER WORKSHOP



MAIN EXPERIMENTAL AREAS

Effects of irradiation

Accident situations

Technological developments in components

Fuel design and manufacture

RIA* tests

Hydromechanical thermal-hydraulic loops

UO₂ LAB
LECA-STAR

CABRI

TOTEM
POSEIDON

Technological irradiation

LOCA* tests

Sodium &

molten-salt loops

PAPIRUS

Post-irradiation examinations

Corium tests

Radiochemistry

LECA-STAR
JHR NDT BENCHES

PLINIUS

LARC
ATHENA

* RIA: Reactivity Insertion Accident
* LOCA: Loss Of primary Coolant Accident

↑ Our R&D resources

Example of a project

Design and innovation: TOMIS, a powerful tool for the physical characterisation of packages using in situ tomography.

The TOMIS project consists of a high-energy tomography device, installed in a container, for the 3D characterisation of nuclear waste packages. This demonstrator, developed as part of the TOMIS programme supported by ANDRA, can be used to check the content of waste in order to meet storage standards.

Using an electron accelerator to produce a powerful X-ray beam,

it can penetrate thick walls (up to 1m of concrete) and inspect various materials.

The innovation lies in its mobility, enabling analyses to be carried out directly on site, without having to transport the materials to be characterised.

TOMIS was commissioned in December 2023. A CEA facility at the Cadarache site has used TOMIS for industrial measurement campaigns on historic nuclear waste packages.

TOMIS, a new turnkey technological solution, could be of interest to French and international nuclear manufacturers.





Example of a project

Experimentation: studies of fuel behaviour in an accident situation in the CABRI reactor.

The institute operates the CABRI research reactor at Cadarache, which is used to study the behaviour of nuclear fuels subjected to power peaks. The IRESNE teams are responsible for preparing, conducting, studying and analysing the tests.

Thanks to a helium-3 depressurisation system, it is possible to achieve rapid reactivity transients with power peaks up to 20 GW (GigaWatts) over durations ranging from 10 to 90 milliseconds. The instrumentation set up enables to monitor the response of the experimental fuel rod to these power injections.

The CIP (CABRI International Programme) research programme led by the IRSN (which became the ASNR in 2025), under the aegis of the OECD, aims to improve knowledge of the behaviour of the fuel in pressurised water reactors such as those in France's nuclear power plants. The tests use different types of irradiated fuel and aim to assess their response under accident conditions, by simulating reactivity transient scenarios.

The data obtained is essential for adapting and improving nuclear reactor safety models and for defining even more robust standards.

The results are eagerly awaited by the international community.

Example of a project

Instrumentation and measurement: acoustic instrumentation in extreme environments.

The institute develops acoustic instrumentation applicable in extreme environments, i.e. at very high temperatures and pressures under irradiation.

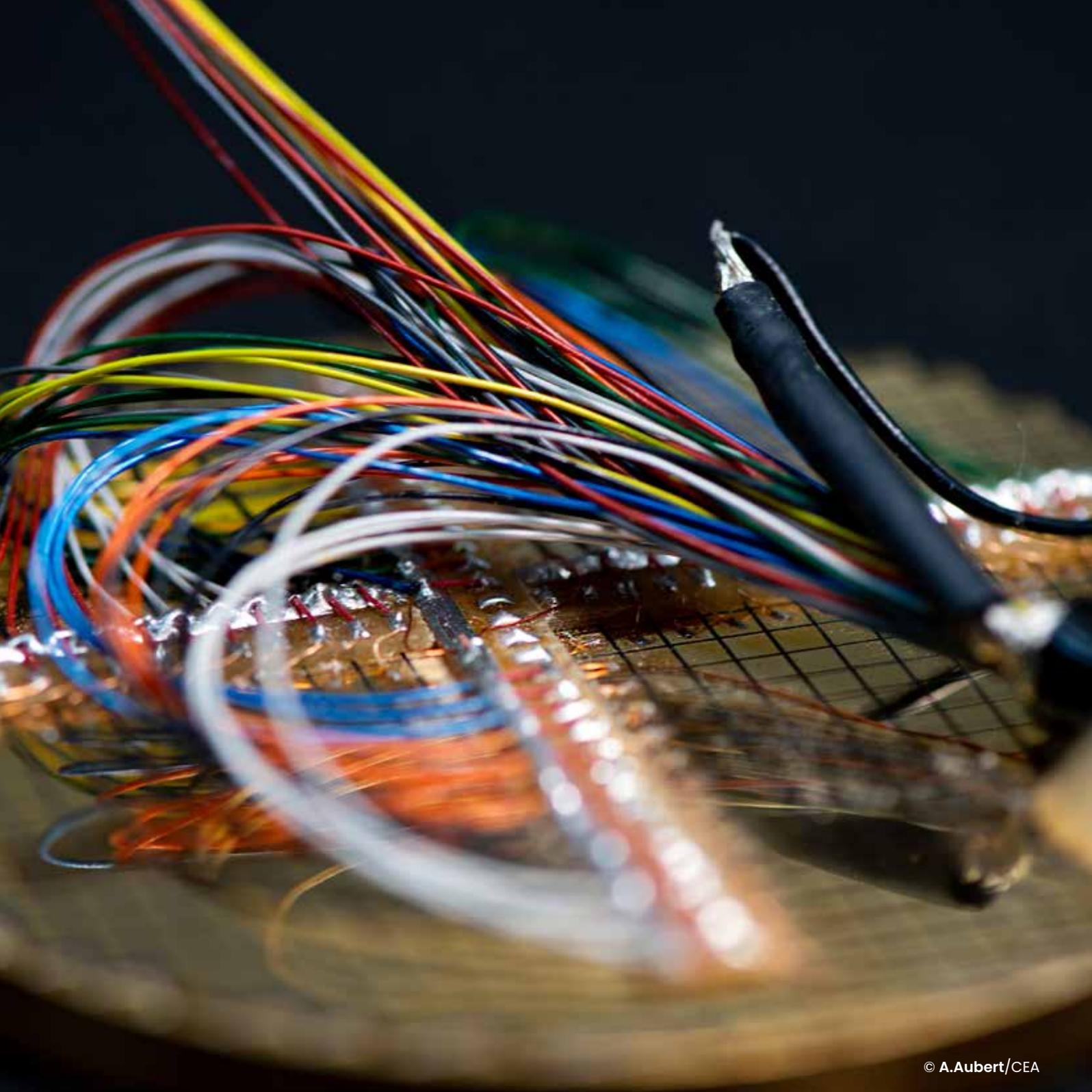
The TUMBT/TUMHT (Low and High Temperature Multi-element Ultrasonic Transducer) sensor, developed in partnership with the FEMTO-ST (Franche-Comté Electronics Mechanics Thermal Science and Optics - Sciences and Technologies, joint research unit (UMR) 6174) and the Institute of Electronics and Systems (IES), is an acoustic multi-element transducer for imaging in liquid sodium (opaque medium).

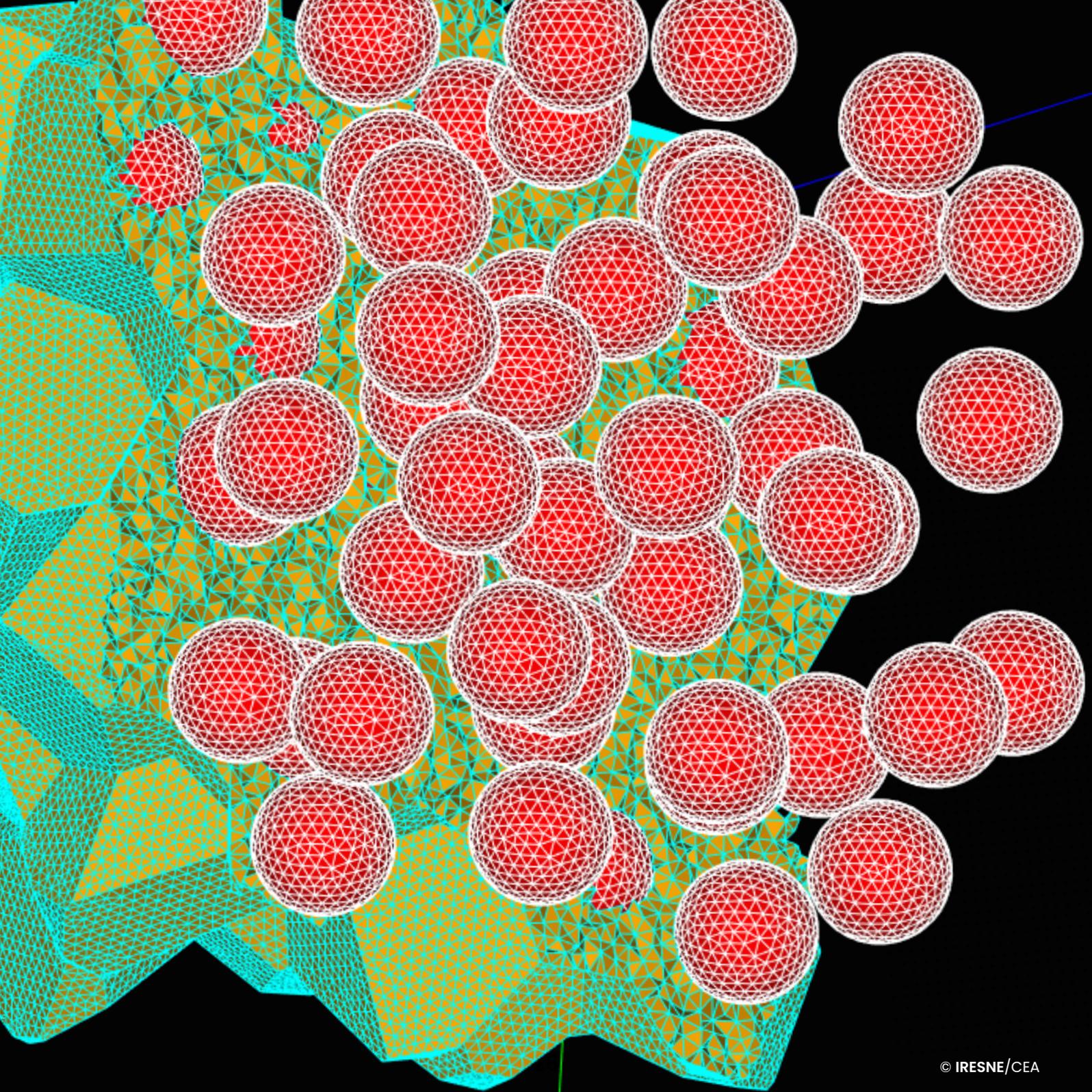
This sensor is based on a piezoelectric lithium niobate crystal.

This so-called "in-core" instrumentation is considered to be an improved version of the TUSHT (High Temperature Ultrasonic Transducer), playing the role of telemeter, rate meter, defectometer and imager.

It operates with liquid sodium at 550°C and can be used in sodium-cooled fast reactors (4th generation reactors). It has a wide range of applications, including non-destructive testing such as telemetry, imaging, flow measurement and gas presence measurements. Research is now underway to further improve its acoustic performance.

This instrumentation enables continuous monitoring or periodic checks of reactors when shut down.





Example of a project

Modelling and simulation: from modelling fuel behaviour to simulating lithium-ion batteries.

In a Li-ion (lithium-ion) battery, during the charge and discharge phases, the silicon inclusions are subject to variations in volume due to the insertion of lithium ions. These variations in volume lead to significant variations in the dimensions of the particles, which are then subjected to severe mechanical stress.

This problem is fairly similar to that encountered during the irradiation of nuclear fuel, in particular heterogeneous MOX fuel, a mixture of mixed uranium and plutonium oxides. This can undergo differential swelling, which generates mechanical stresses that can lead to irreversible deformation.

As part of the PLEIADES digital platform for simulating the behaviour of nuclear fuels, IRESNE is developing digital tools to simulate the mechanical behaviour of materials with inclusionary phases.

Applied to battery electrode materials, these tools have enabled us to make rapid progress in describing the mechanical behaviour of a lithiated silicon particle.

A semi-analytical elasto-viscoplastic model has been developed to reproduce the experimental observations.

The aim of these multi-scale simulation studies is to increase the capacity of battery anodes to absorb the lithium.

WORK WITH IRESNE

Since its creation, the CEA has supported businesses and contributed to the drive for **innovation**. It puts its **expertise** and **technologies** at their service. Hundreds of small and medium-sized enterprises, as well as major industrial groups, are conducting their innovation programmes with the CEA, and in particular with **IRESNE**.

WHY BECOME A PARTNER?

Recognised scientific excellence

The CEA supports industrial innovation through so-called technological research, which is based, for each sector of activity, on fundamental research of excellence.

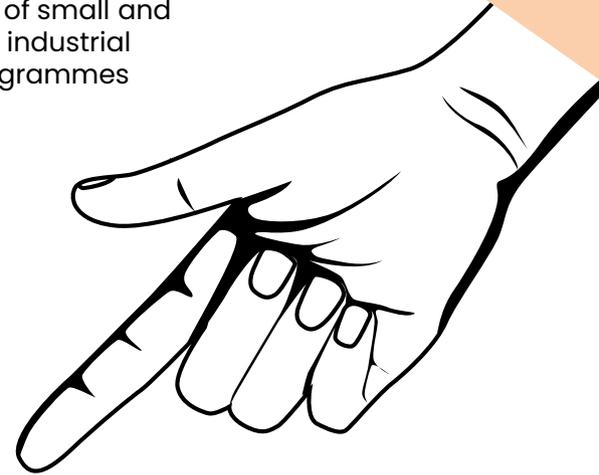
Innovative and secure research

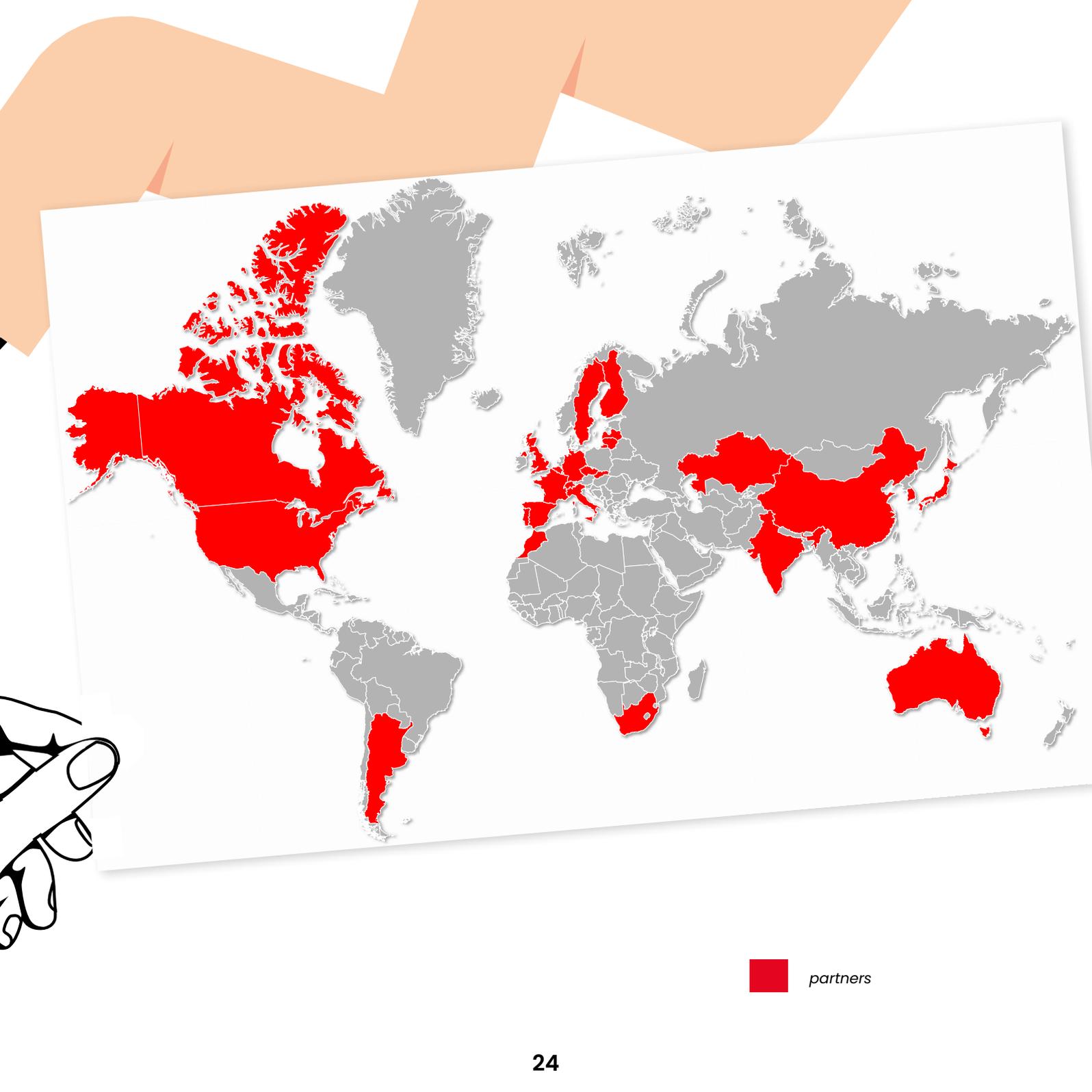
Control of intellectual property is a key part of the CEA's strategy, applied to the transfer of innovation to businesses.

Access to state-of-the-art technological equipment

The CEA has acquired extensive experience in the design and operation of very large research infrastructures. In addition to this expertise, the CEA manages state-of-the-art technological platforms that are open to companies.

IRESNE is a CEA research and development institute. Working with IRESNE allows access to all the institute's R&D resources, as well as those of the CEA.





partners



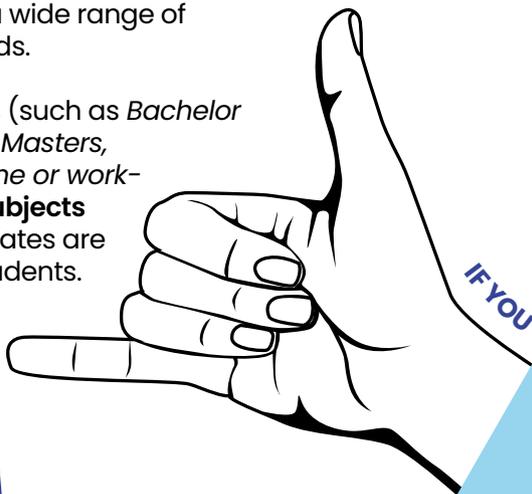
JOIN IRESNE

Whether it's for a **job**, a **doctorate**, a **post-doctorate**, a **work-study program** or an **internship**, every year IRESNE looks for new talent to help *carry out R&D missions and innovate on a daily basis*.

For research support **engineers, researchers, technicians and staff**, there are numerous opportunities available in a wide range of scientific and technical fields.

150 subjects for internships (such as *Bachelor of Technical Studies (BUT), Masters, Engineering school (full-time or work-study program)*) and **50 subjects** for theses and post-doctorates are published each year for students.

Interested in science?
Learn through research
at **IREsNE!**



IF YOU
ARE INTERESTED,
WE'RE INTERESTED IN YOU!

Our job offers



Our internship and
work-study opportunities

Our thesis and
post-doctorate offers



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