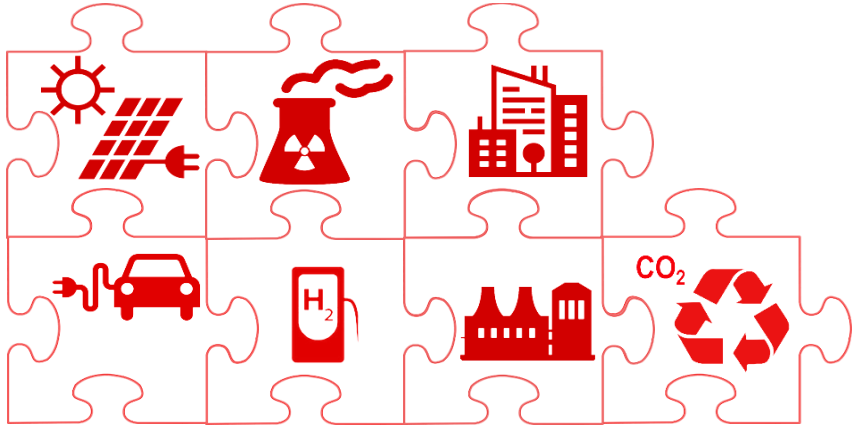

Accelerate the energy transition
Context and R&D activities

Heloise GOUTTE

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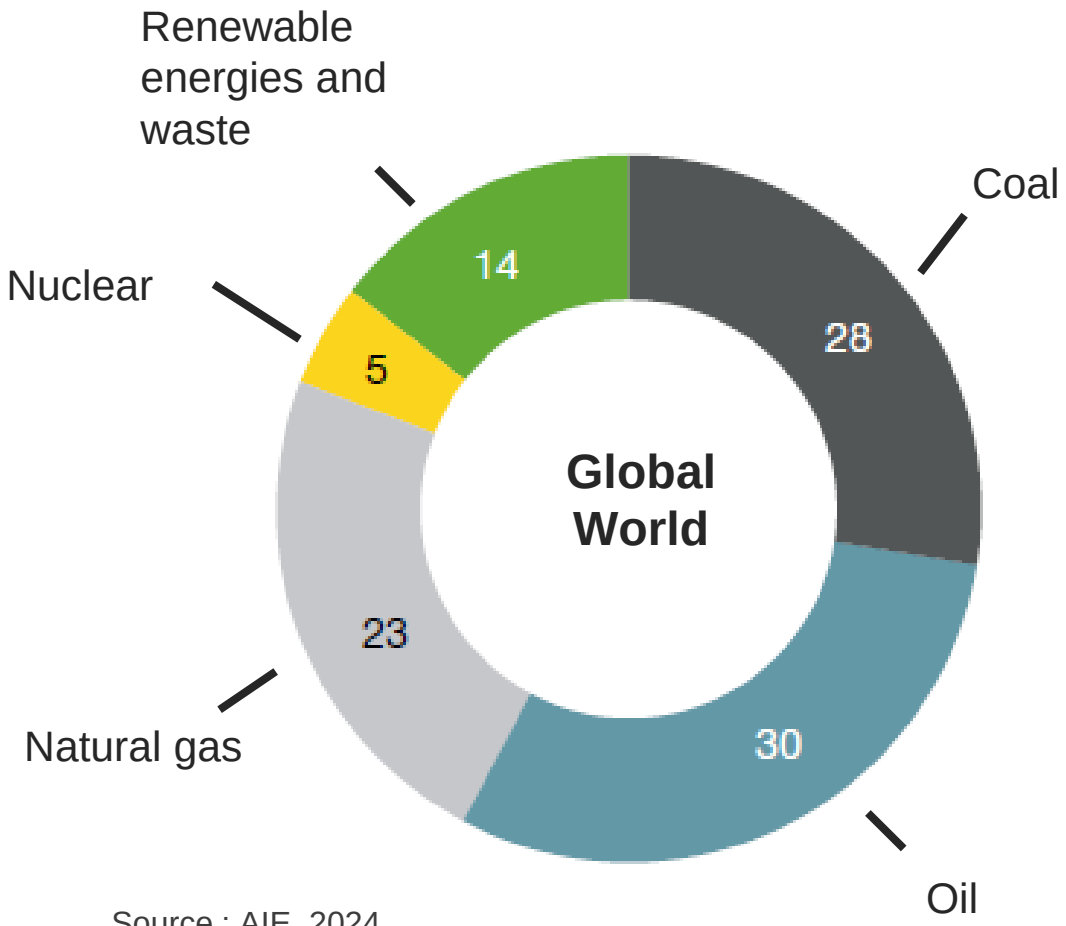
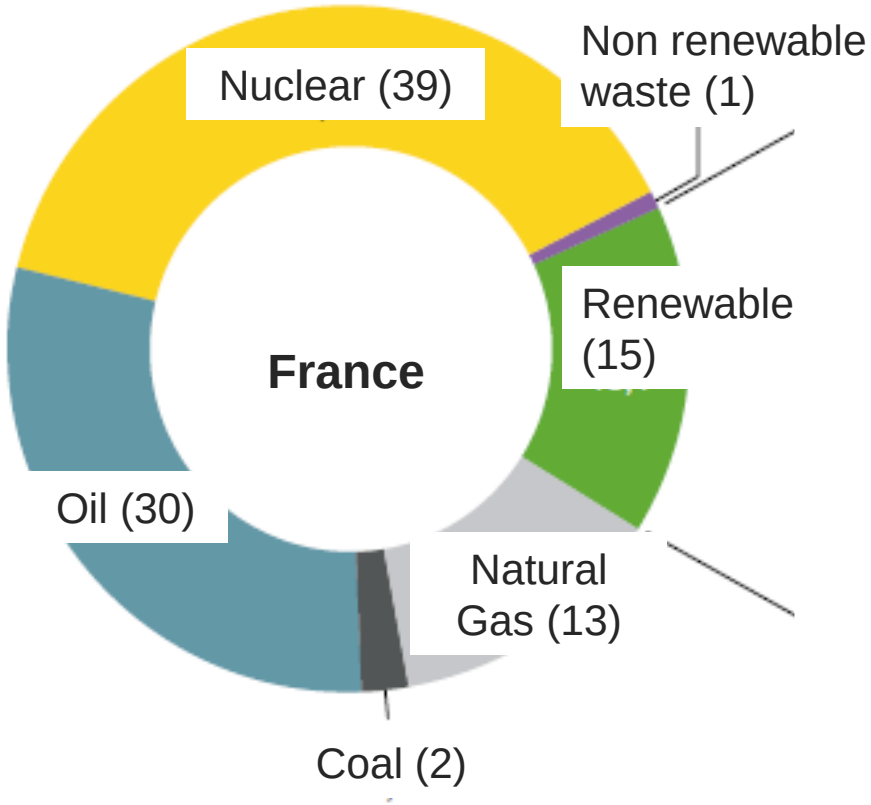
Primary energy consumption breakdown

Global primary energy consumption by source (%)

Source : SDES, Bilan énergétique de la France



Source : AIE, 2024



→ **Electrification plan**

→ **But decarbonization must go beyond electricity (transport, industry, buildings …)**

Our carbon footprint

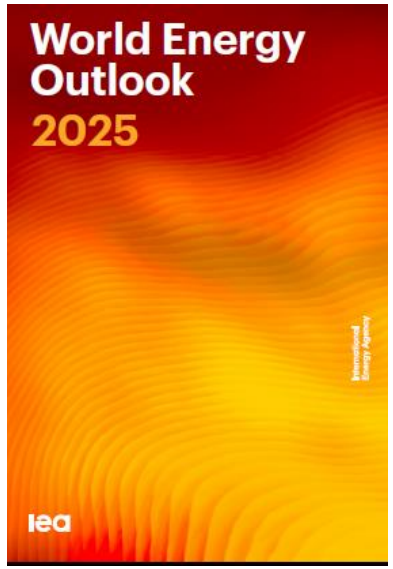
Source : SDES-Insee

Carbon footprint of the French in 2021

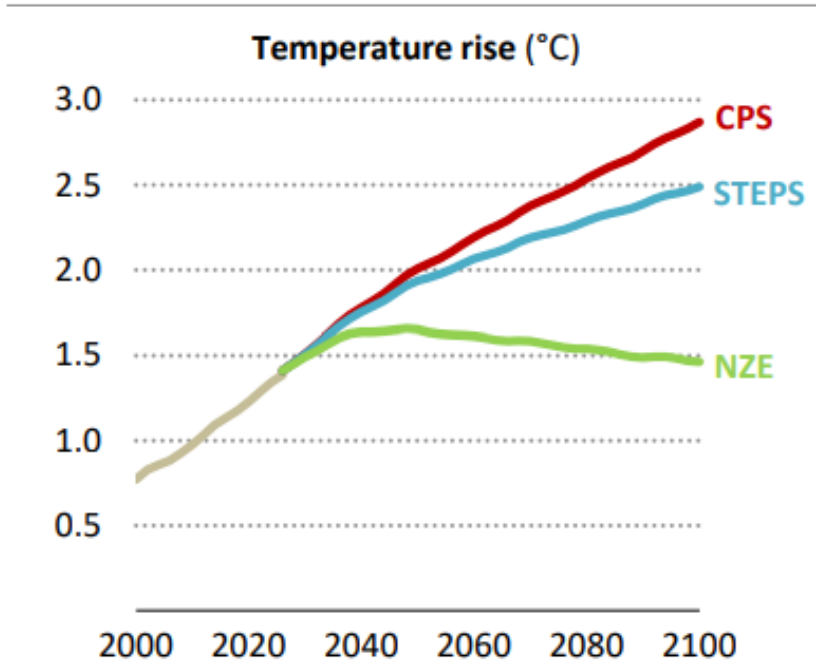
9,8 t
Per capita

55 %
of the carbon footprint is associated with imports

Outlook



https://www.iea.org/reports/world-energy-outlook-2025



The average temperature rise reaches 2.9 °C in 2100 in the CPS, 2.5 °C in the STEPS, and in the NZE Scenario it peaks at around 1.65 °C in 2050 and falls below 1.5 °C in 2100

CPS : Current Policies Scenario
STEPS : Stated Policies Scenario
NZE : Net Zero Emissions by 2050

- CPS 2025 scenario = +2,9°C in 2100,
- CPS 2019 scenario = +4°C

→ 45% of the innovations needed to achieve carbon neutrality have yet to be developed

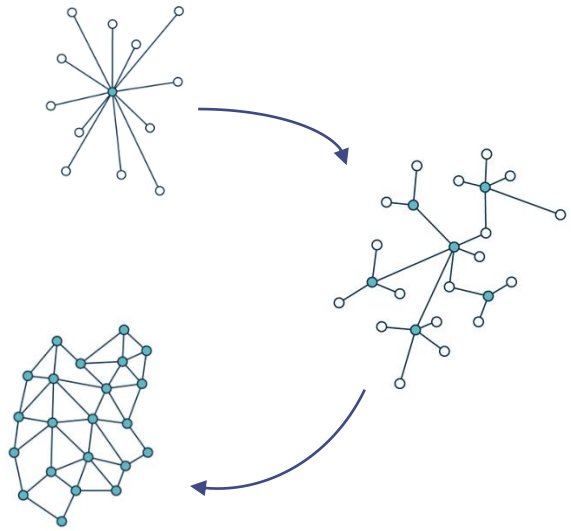
Net Zero by 2050 - A Roadmap for the Global Energy Sector – IEA, May 21

Energy transition : key findings and R&D pathways

No single option can provide a short- or medium-term solution in terms of energy source or energy vectors

One dependency should not be exchanged for another (materials …)

We need to manage the growing complexity of networks



Two key levers

Energy efficiency

Improving the performance of processes, equipment, and buildings

Sobriety

Reduced consumption, based on a change in lifestyles (at both individual and collective levels)

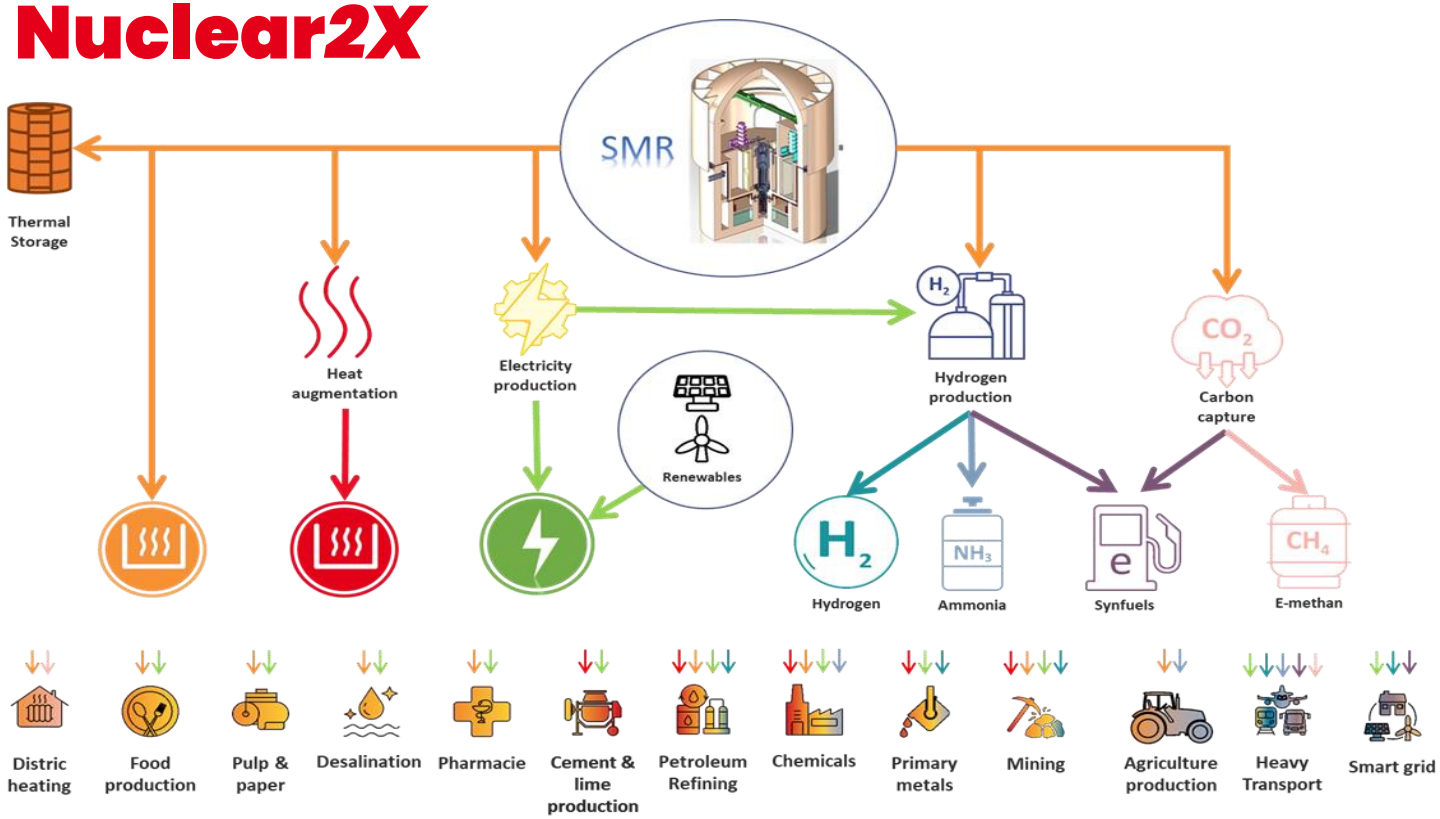
Electrification is a major part of the solution.

But it cannot cover all needs, notably in heavy mobility and industrial sectors.

Effective storage methods will be essential (daily, seasonal…)

An integrated vision of the energy system

Small (advanced) modular reactors Nuclear2X



► ❶ High / very high temperature heat

►❷ Hydrogen production

►❸ Production of fuels and synthetic molecules (e-fuel)

1G/2G biofuels will not meet the demand (biomass ressources)

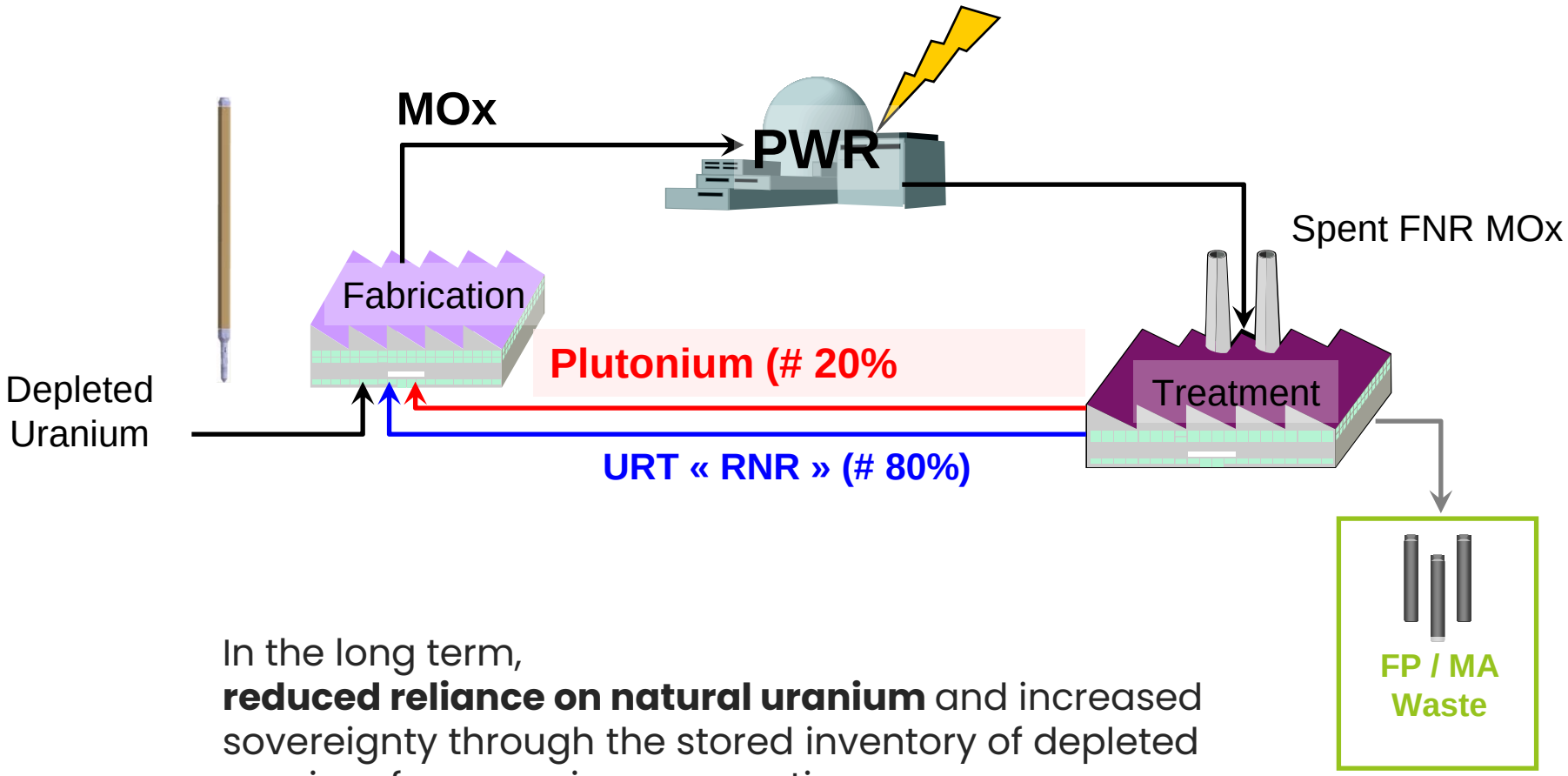
Long-distance transport cannot be ensured by electrification and hydrogen.

- Sustainable fuels from CO2 (e-fuel, e-bio-fuel)

- Synthetic molecules (methane, methanol, ethylene) from CO2

Closure of the fuel cycle

= multi-recycling in fast neutron reactors (Gen 4)



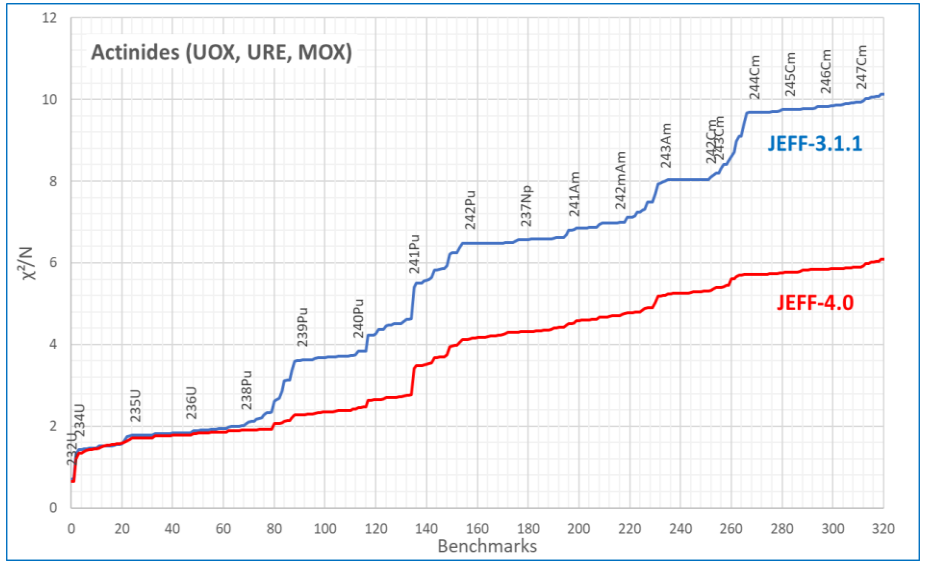
In the long term,
reduced reliance on natural uranium and increased sovereignty through the stored inventory of depleted uranium from previous generations

Highlight – Nuclear data

The JEFF-4.0 Nuclear Data Library (Joint Evaluated Fission and Fusion) available since June 19, 2025, at the Nuclear Energy Agency's Data Bank.

The performance of the JEFF-4.0 library has been significantly improved compared to the JEFF-3 library :

- particularly for light water reactor calculations such as :
  - power distribution,
  - reactivity as a function of burn-up,
  - isotopic inventory in irradiated fuels,
  - and decay heat
- as well as for studies related to the design of advanced nuclear reactors.



https://databank.io.oecd-nea.org/data/jeff/40/

Highlight– Decontamination and dismantling

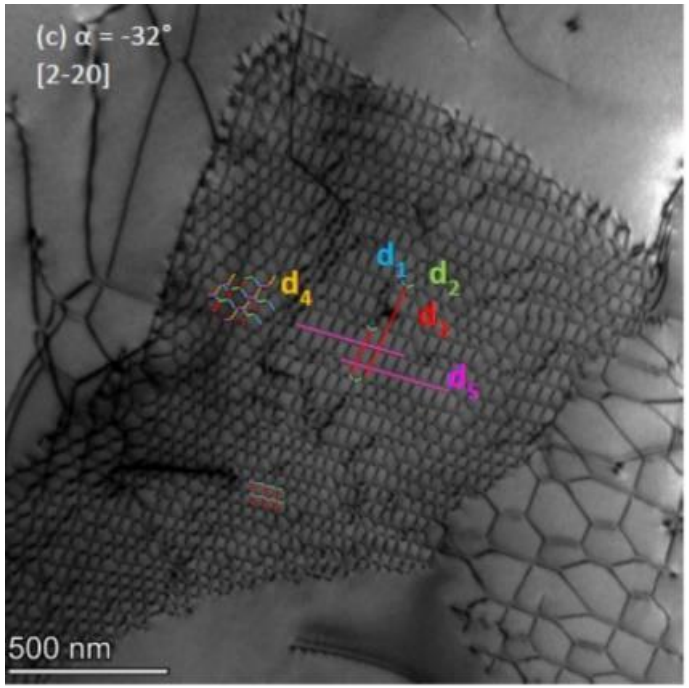
TOMIS (In Situ TOMography)

Qualification of the tomograph using actual packages

The **TOMIS project** aims to integrate and demonstrate the feasibility of **high-energy 3D tomography** in a **mobile and autonomous version**, enabling the deployment of this technology directly on **waste package production and storage sites**.

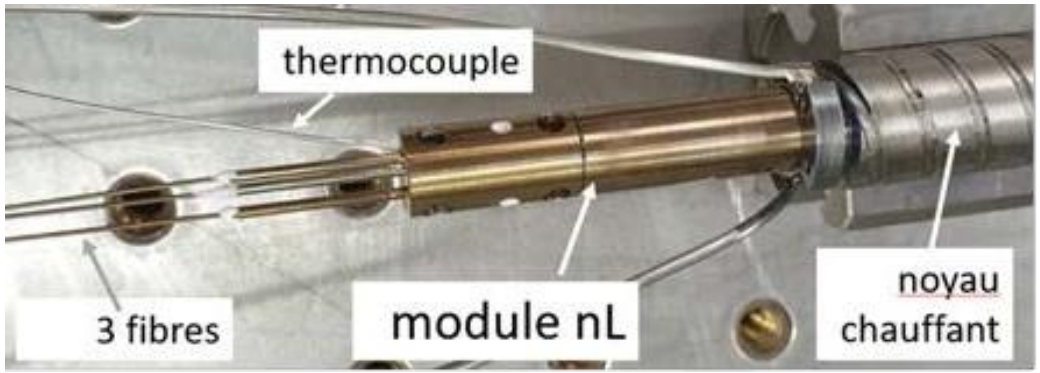
Highlight- Materials

Characterization of dislocation behavior in UO_2



Objective: Improve the modeling of viscoplastic behavior of fuel at the nanoscopic scale

Highlight- Irradiation of optical fiber sensors



Qualification of optical fiber sensors under irradiation

They will instrument devices in the core of nuclear research reactors such as the future Jules Horowitz Reactor (RJH).

The sensors remained operational throughout the entire cycle.

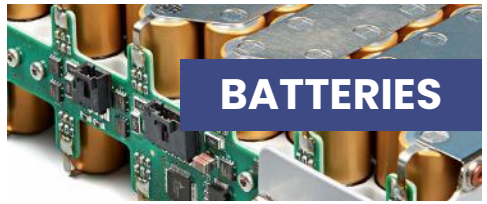
They operated at temperatures between 250 and 500 °C..

R&D roadmap for New Energy Technologies

R&D Technologies

Prototyping and integration

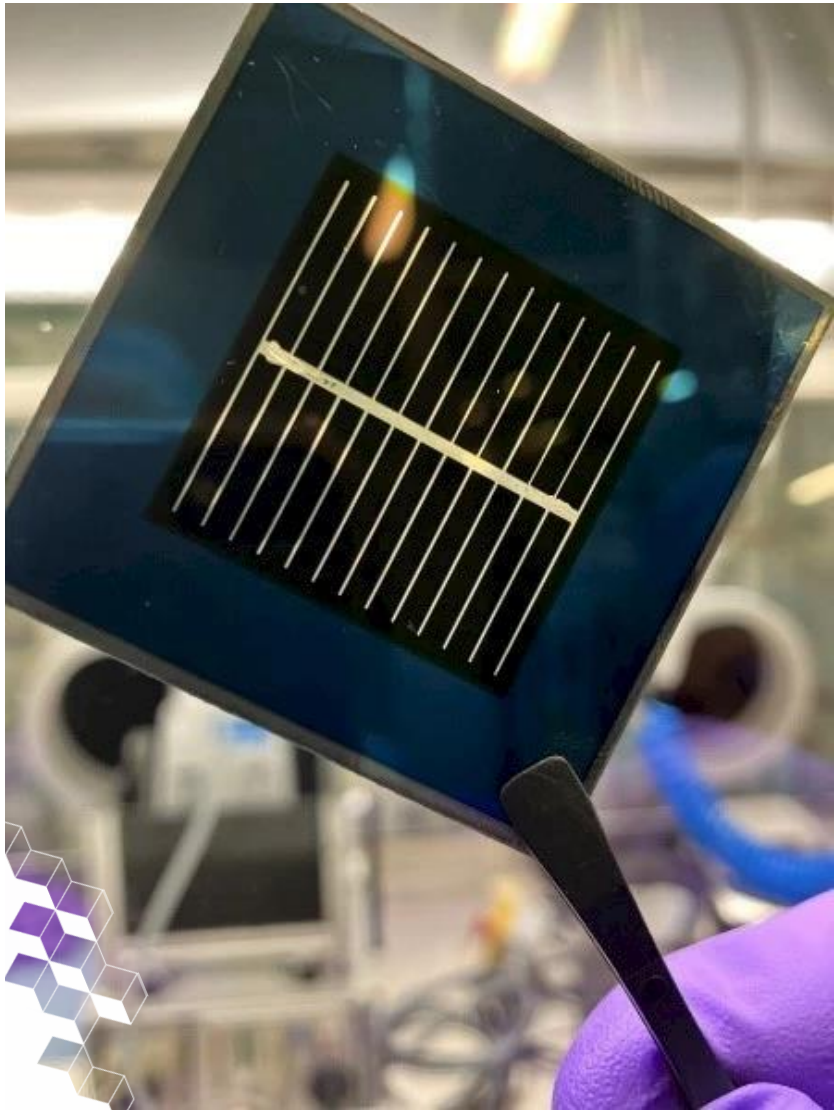
Transfer to i dustry (demonstration & production)



Highlight : photovoltaic cell

- **CEA and 3SUN break a new record for photovoltaic cell efficiency !**

  As part of the joint development program between CEA and 3SUN on tandem perovskite-on-silicon **solar cell** technology, a new milestone has been achieved, setting a new **efficiency record of 30.8%** *(certified)*



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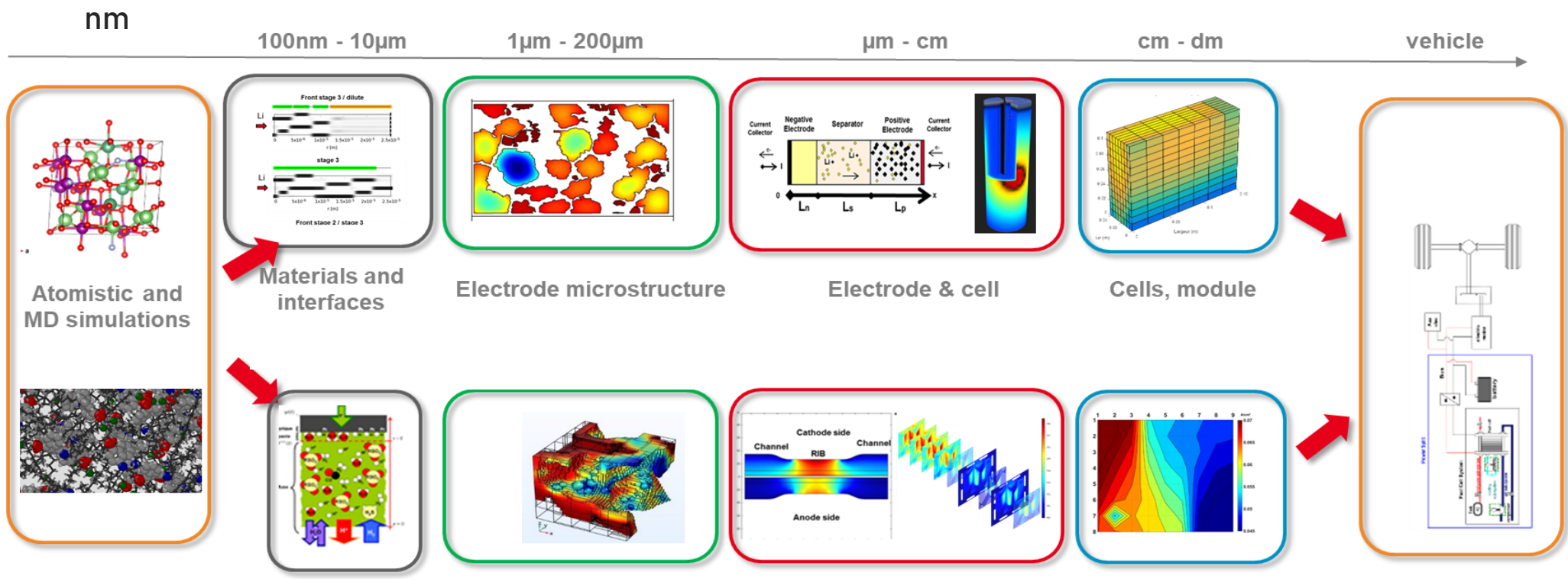
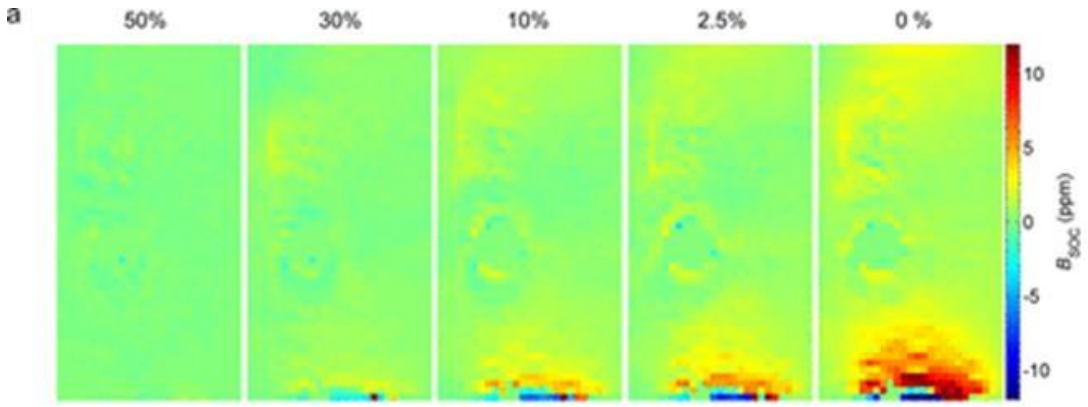
Multi-scale approach



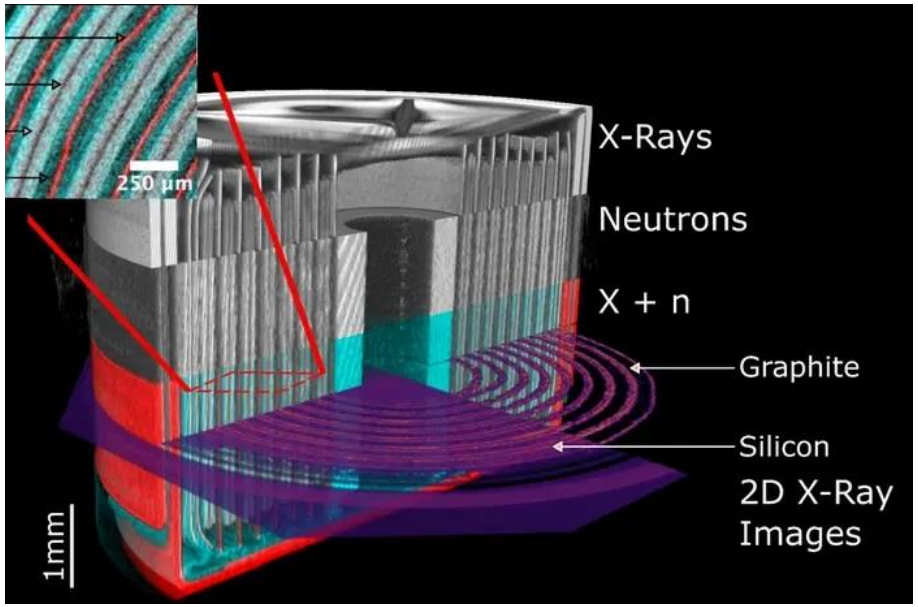
Highlight- Operando characterizations of batteries

Operando methods (X-ray, neutrons, NMR, nuclear microprobe, etc.) to understand mechanisms and aging (interfaces & morphology)

Operando NMR imaging of Li-Ion pouch cells



Origin of defects in the core of a lithium-ion battery analyzed by X-ray and neutron imaging



3D visualization of a Li-ion battery cell: combined image from neutron and X-ray characterization techniques *(© Erik Lubke – ILL).*

Towards strengthening collaborations and joint work between the GANIL community and the energy sector’s R&D ?

Thank you for your attention