Energy and sustainable development

In order to reduce the use of fossil raw materials, it is urgent to turn to other energies - including solar, wind, or based on the catalytic conversion of biomass - whose production and storage must be improved. Technological progress in these fields, to which SOLEIL will contribute, must be compatible with sustainable development and its implications in economic, societal, and environmental terms.

In addition, studies to optimize the nuclear fuel cycle will also benefit from the Upgrade.

CARBON-FREE ENERGY SOURCES

Designing economically viable fuels from sustainable resources such as biomass to reduce greenhouse gas emissions; developing cleaner and more efficient fuel combustion processes to take full advantage of existing stocks; optimizing solar energy conversion: these are the avenues to be explored considering the urgent need to accelerate the transition to carbon-free energy sources.

SOLEIL UPGRADE

Upgrade of SOLEIL: Increase of the brightness + focusing of the photon beam =
→ Contribution to the development of renewable energies (hydraulic, wind, solar, geothermal, or from biomass) to fight against global warming.

MORE EFFICIENT INDUSTRIAL CATALYSTS

More than ¾ of the manufactured objects that surround us are obtained by catalytic processes. These allow selective reactions (the desired substance is produced with a much higher yield), efficient (less loss of initial components), in conditions (temperature, pressure...) less energy consuming.

One of the challenges in many industrial fields is to understand them in detail and to optimize them to significantly reduce energy consumption.

SOLEIL UPGRADE

Upgrade of SOLEIL: Increase of the brightness and coherence of the synchrotron radiation =
→ Study of catalytic reactions under real conditions and in real time.
→ Better understanding of catalyst activation mechanisms.
→ Recommendations to obtain more efficient catalysts.

THE BATTERIES OF TOMORROW

In order to develop the use of intermittent or renewable energies, one obstacle remains to be overcome: optimizing their efficient storage, in the longer term, with more abundant and cleaner materials. Batteries are therefore a crucial element. Tomorrow's batteries will be cheaper, free of lithium or cobalt, able to detect and repair their own failures and will have a high energy storage density.

SOLEIL UPGRADE

Upgrade of SOLEIL: Increase of photon flux + coupling with automation & artificial intelligence methods (BIG-MAP project*) =
→ Identification or design of new materials for energy.

More information onback page

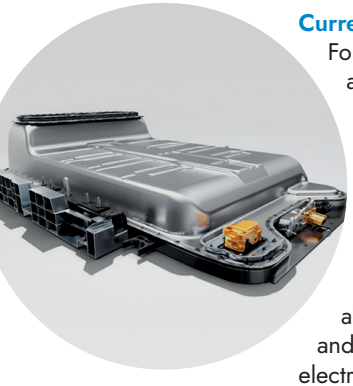
* https://www.big-map.eu/

WHICH MATERIALS FOR TOMORROW'S BATTERIES?

F. Eveillard et al., New Journal of Chemistry, 44, 15297-15298 (2020)
B. Li et al., Nature Chemistry, 13, 1070–1080 (2021)

As essential elements of our daily lives, we expect batteries to perform better and better. Storing energy for longer periods of time is a problem that has mobilized researchers for several decades, but there is now a growing environmental requirement to use cleaner materials.

Achieving ultra-high electrochemical performance in safe and durable batteries requires overcoming technological challenges in both materials and chemical engineering.



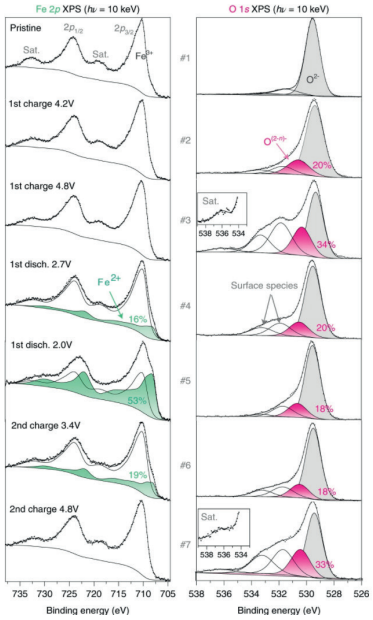
Battery of the Zoe electric car (©Renault).

Current responses from SOLEIL:

For nearly 15 years these questions have been studied at SOLEIL. One of the «pluses» of the research carried out are the measurements performed on batteries in operation (operando), which make it possible to link the electrochemical performance of the battery and the structural and electronic state of its material in operation.

Currently, among the avenues being explored: mastering «anionic redox» technology, which could almost double the energy capacity stored in the battery and thus its autonomy, or improving the stability of electrode-electrolyte interfaces (RS2E* network).

* https://www.energie-rs2e.com/fr



Example of data recorded by the X-ray spectroscopy technique "HAXPES".

UPGRADE OF SOLEIL

Increase of the photon flux

+

Better focusing of the photon beams

+

Use of beam coherence properties

=

Study of operando materials and elaboration of new materials by reverse design

The SOLEIL Upgrade will enable the study of battery materials in operando conditions, thanks to a set of advanced, complementary, and high-throughput (large number of samples analyzed) analytical techniques, performed following protocols optimized by automation and artificial intelligence methods.

Unique information on chemical, morphological and structural changes inside electrodes and electrolytes will be accessible, on size scales ranging from mm to nm, with high spatial and temporal resolutions (10^{-11} s).

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