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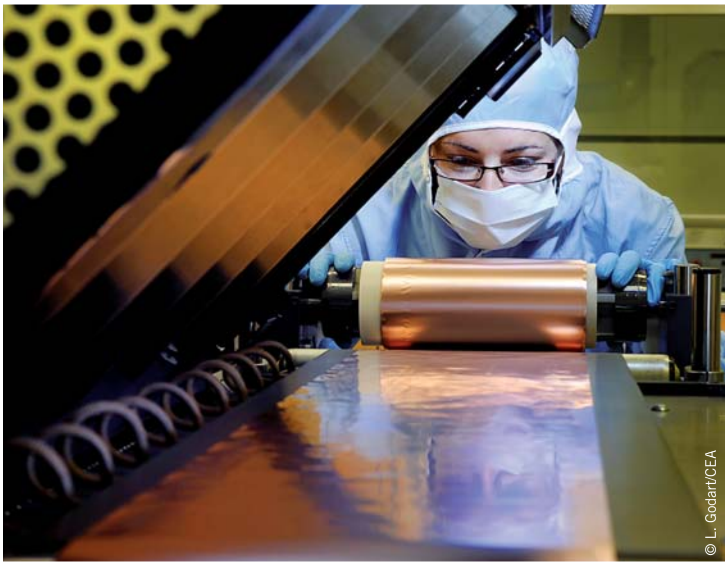
EXPERT IN LOW-CARBON ENERGIES

Reducing dependence on fossil fuel imports and maintaining low energy prices, while preserving the competitiveness of the energy industry and avoiding greenhouse gas emissions: these requirements are driving the energy transition initiated by France in the early 21st century, and CEA is playing an active role. For about twenty years, its staff have been innovating with the technological buildings of an energy mix (nuclear, solar, biomass, hydrogen) in three fields (transport, buildings, electrical grids) focusing on the problems of energy storage and efficiency. The aim is to address rising energy needs, by combining a stable base energy, such as nuclear, with intermittent energies. To meet these challenges, CEA also initiates partnerships with other industrial and academic players. So it was no surprise that in October 2011, it succeeded the IFPEN[1] as President of Ancre[2], an alliance of public research organizations working to identify priority scientific and technological hurdles in the energy sector and propose coordinated research programs.

In terms of coordination, the nuclear sector has the experience that comes with age …as does CEA, which has accompanied with the nuclear power generating >>>

notes: 1. The French Petroleum and New Energies Institute (IFPEN) was the revolving President of Ancre for 2 years. 2. National alliance for energy research coordination, comprising 19 research organizations and 9 thematic groups. http://www.allianceenergie.fr

Culturing micro-algae for the production of 3rd generation biofuels at CEA-iBEB in Grenoble



Producing an electrode for an electric vehicle lithium-ion battery at CEA-Liten in Grenoble

>>> industry in France since the 1970s. Its Nuclear Energy Division (CEA-DEN) currently divides its efforts between support for industry (Areva, EDF) working on the reactors of today and tomorrow, and research into the reactors of the future, known as the "fourth generation". In its Saclay, Marcoule and Cadarache centers, R&D on current water reactors is innovating both with regard to reactor operation, up to and including decommissioning, and the management and disposal of radioactive waste. The main goal is to extend reactor service life while improving performance and safety. This was made all the more necessary by Fukushima. In the wake of this accident, CEA boosted its R&D work (particularly for corium behavior and hydrogen) and its safety management, tested during reinforced exercises with scenarios involving combinations of extreme events. With regard to the fourth generation: "the goal is to develop nuclear power that is safer and more competitive, less demanding of resources (using more than 90% of the uranium as opposed to 1% in today's reactors) and reducing the quantity of long-term waste produced," explains Frank Carré, Scientific Director at CEA-DEN.

> The aim is to adress rising energy needs by combining a base energy with intermittent energies

Sodium-cooled option preferred

This research, governed by the Act of 28th June 2006, focuses on two fast neutron reactor systems: one sodium-cooled and the other gas-cooled. Priority is being given to the "sodium" option, for which CEA – together with its industrial partners and the support of the CGI[3] through the Investments for the Future program – is developing the Astrid prototype project for the 2020 time-frame. Its work is built around basic research in physics, chemistry and materials, and it is developing numerical simulation programs and major experimental infrastructures. For example, the RJH experimental European reactor, under construction at Cadarache, will take over

note: 3. General commissariat for investments

NUCLEAR FUSION

TOWARDS A NEW SOURCE OF ENERGY

How can we recreate the energy reactions that take place in the stars here on Earth? Those are the stakes involved in nuclear fusion, a process in which two atomic nuclei come together to form a heavier nucleus under very specific conditions: generating 500MW while only consuming 50 for 406 seconds, and maintaining the fusion reactions in a plasma for 3000 seconds. For fifty years now, research has been ongoing worldwide to meet this challenge. CEA is working on the problem at Cadarache on its Tore Supra, an experimental fusion reactor using magnetic confinement. The power and temperature scales are so great that, in 1986, 34 countries decided to come together on the international Iter project, even while they continued with their own research. Construction began at Cadarache in 2007, with the aim of demonstrating the scientific and technical feasibility of controlling thermonuclear plasma in a reactor by 2020.

Inspecting photovoltaic solar modules developed by CEA-Liten at Ines

Developing fuels for 4th generation reactors in Atalante shielded cell at the CEA Marcoule Center

from the Osiris reactor in Saclay, for testing of new materials and fuels. "Alongside major issues such as operating the French nuclear power plants and preparing for the fourth generation, it is important to maintain a technology watch on disposal and grid technologies to optimize the joint use of nuclear and renewable energies. CEA and its partners at the Ancre alliance can bring to bear all the skills and expertise needed for this," concludes Frank Carré.

Studies on technological building blocks

Joint work on nuclear energy and renewables began at Cadarache in 1990. This came about through a sharing of expertise, enabling the Genec laboratory to conduct research into solar energy. Since then, these activities have been transferred to Ines[4], bringing together the teams in the Grenoble region, where CEA-Liten was set up in 2006. The initial focus was on solar photovoltaic energy, with teams achieving electrical conversion efficiency levels of 21%, with the goal being 24 to 25%. "We have just transferred some of our activities to LabFab at Ines. This small plant, with a 35MW capacity should enable us to validate the economics of the model by working within the same constraints as an industrial firm," states Didier Marsacq, Director of CEA-Liten. Concentrated thermal solar power is the second approach, developing several technologies, depending on anticipated power levels and their combination with other applications. "We have recently become interested in this area and are permanently innovating, at all levels, thanks to a prototype plant at Cadarache," says Nicole Mermilliod, Cross-disciplinary Programs Manager at CEA New Energy Technologies (NTE).

CEA also places high hopes on another key resource, biomass, which produces chemical components with high energy value. The thermochemical transformation of ligno-cellulosic feedstocks, which has been studied in Grenoble since 2005, is capable of producing 2nd generation biofuels with better than 30% efficiency, through the addition of hydrogen during the conversion process. Innovations in this field focus on the technological building blocks of torrefaction and gasification processes, as in the BioTFuel project. At the same time, CEA is examining the technical and economic feasibility of a complete production line for biodiesel and biokerosene on a single site. It is hoped that the Syndièse pre-industrial demonstrator in Bure-Saudron will be the precursor to a French industry in this field. CEA is also concentrating its research on overcoming the technological obstacles to 3rd generation biofuels. For more than 15 years, the laboratories at Saclay, Fontenay-aux-Roses and Cadarache analyzed the ability of micro-organisms to produce hydrogen, ethylene and other energetic compounds such as lipids. The recent inauguration of the Heliobiotech platform in Cadarache should enable CEA-iBEB researchers to increase this area of production. Of all the technological building blocks developed at CEA, hydrogen is looking promising for various types of applications. In 2006, the researchers at CEA-Liten successfully used it as a fuel in a fuel cell developed in partnership with PSA Peugeot Citroën; this cell will power certain types of vehicles in the future. Hydrogen and fuel cells are also useful as a back-up to intermittent energy sources. At the Corsican branch of Ines, CEA and the Hélion >>>

note: 4. French national institute of solar energy, created in 2005 near Chambery by CEA, the CNRS and the University of Savoie

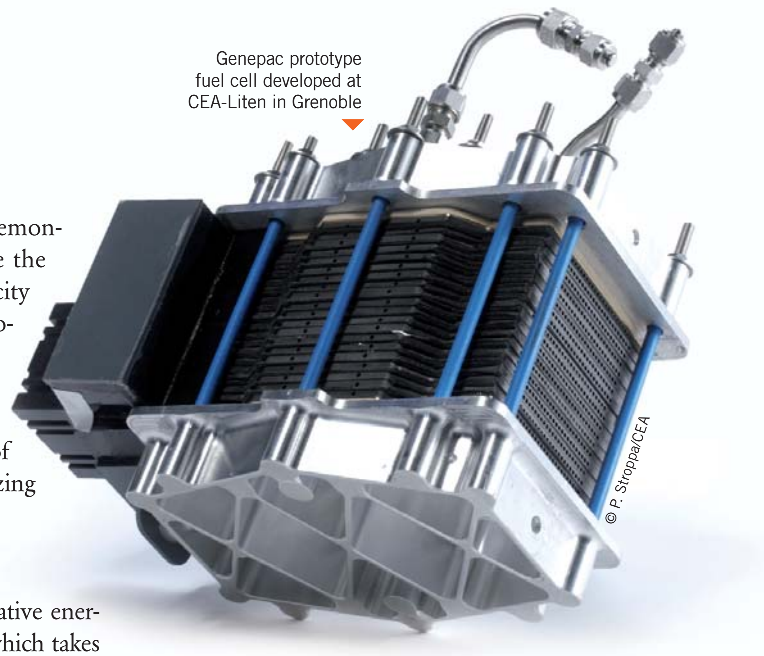
Solar photovoltaic // Technology that converts sunlight (photons) directly into electricity

Concentrated thermal solar power // Technology that converts sunlight (photons) directly into heat

2nd generation biofuels // Synthetic fuel produced from organic materials contained in forestry residues and parts of plants not in competition with foods, such as straw

3rd generation biofuels // Synthetic fuel produced from energetic compounds produced by micro-organisms such as algae or cyanobacteria

Fuel cell // Device that produces electricity from the oxidation of hydrogen on an electrode, with water as its only reaction product



Genepac prototype fuel cell developed at CEA-Liten in Grenoble

>>> company are starting up a massive storage demonstrator coupled with a solar farm, to validate the following model: solar energy provides electricity to supply an electrolyzer that produces hydrogen. The hydrogen is stored or used to generate electricity, via a fuel cell. Parallel research aims to bring down fuel cell manufacturing costs, in particular by reducing the quantities of platinum used in its components, and optimizing the capacity and safety of the storage tanks.

Storage is key

Storage is in fact the key to developing alternative energies. The goal here is to meet rising demand which takes the form of a significant increase in consumption peaks. As these intermittent energies are not available all the time, it must be possible to store them. CEA adopts several approaches: on the one hand, the joint use of various energy resources (nuclear, solar, biomass, hydrogen); on the other hand, the development of different storage technologies depending on the applications, some of which were inherited from the nuclear field, such as thermohydraulics for thermal storage. In this example, heat is stored during the summer in phase-change materials capable of releasing it as the seasons change. "The three houses in the Incas project run by Ines are a means of testing massive seasonal storage according to the inertia of the building, its construction materials, and so on," says Didier Marsacq, who goes on to talk about the transportation applications: "We have developed a lithium-ion batteries technology that gives a vehicle a range of 150 km right now. Our goal is to double this, while reducing costs and optimizing the safety of the components." To achieve this, the Steeve platform opened in Grenoble in 2010 and currently equips about ten cars per month, thanks to its expertise throughout the entire design chain (from battery chemistry to integration of on-board electronics managed by CEA-Leti). Research into nanomaterials is also continuing in Grenoble, at CEA-Inac. This level of skills is attracting partners, such as Renault in 2009, or leading to start-ups, such as Prolion, which manufactures customized batteries for a variety of applications.

> "It is important to maintain a technology watch on disposal and grid technologies to optimize the joint use of nuclear and renewable energies"

Frank Carré, Scientific Director at CEA-DEN

"With all these different sources of electrical energy and consumption modes, supply must be tailored to demand. And as some resources are intermittent, flow forecasting must be improved in order to optimize their availability." This efficiency challenge, as presented by Didier Marsacq, is the whole reasoning behind smart grids. This technology, where CEA is now focusing its efforts, is all about bringing intelligence to today's grids, combined with "smart" vehicles and buildings, in particular in the form of sensors and software. Once again, the expertise of the Leti, List and Liten institutes is pooled, using the Prisme micro-grid test tool at Ines, comprising 80kW of photovoltaic energy, 100kWh of batteries and solar terminals for recharging vehicles. The Incas houses are also integrated into the project for full-scale testing. These technologies are among several Green IT initiatives designed to achieve a better balance between efficiency and reduced energy demand.

To consolidate its expertise both upstream and downstream, CEA is conducting fundamental research to understand the effects of energy usage on man, climate and the environment. At i-Tésé in Saclay, it is also carrying out technical-economic surveys on the manufacturing costs of systems, the availability of raw materials, the lifecycle of materials and more. These analyses will all help guide future research in the right direction, for the long-term.

Electrolyzer // Device that allows for electrolysis: converting electrical energy to chemical energy by electrically separating the chemical components (hydrogen and water) of an element (water)
Smart grid // "Intelligent" electricity management grid that uses IT to optimize production and distribution
Green IT // Concept that uses the latest IT developments to reduce the ecological, economic and social impacts of information and communications technologies, in terms of both their design and of dealing with product life cycles

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