SuperGrid Institute goes live

The SuperGrid research institute has received the green light from the European Commission.

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GRID RELIABILITY & EFFICIENCY HVDC
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The SuperGrid Institute is one of several energy-transition projects promoted and part funded by the French government. It is a collaborative research institute bringing together public and private organisations to develop new technologies for supergrids.

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SuperGrid Institute

Powering the electrical grid of the future

The nine Energy Transition Institutes (ITE) selected by the French government have as their mission to carry out research and development into low-carbon energy. The biggest of them, hosted by Alstom, is the SuperGrid Institute. It brings together partners* from industry, academia and research laboratories in a pioneering, long-term collaborative undertaking to boost development of advanced technology solutions.

The SuperGrid Institute's work will make an important contribution to the transition to low-carbon energy. To dramatically increase the share of renewable energy in the energy mix, future transmission grids will have to offer a special combination of capabilities not available today: long-distance transmission (to connect remote renewable energy sources), subsea or underground energy transport, the ability to handle unpredictable fluctuations in renewable energy generation, and more. Meshed HVDC grids are a promising solution to these issues, but they require that a number of technological challenges be overcome. And that is the ambition of the SuperGrid Institute.

1__A unique opportunity for all the stakeholders

Philippe Auriol, retired professor of the Ecole Centrale Lyon and former director of a CNRS laboratory, has been appointed president of the SuperGrid Institute. A "Distinguished Member" of the CIGRE, he knows the sector well. “This is my domain, having been involved in research in high voltage and grids for a number of years."

The structure is in place with five programmes [see sidebar]. This is a unique opportunity for long-term cooperation among partners from different backgrounds. It is also a great opportunity to accelerate technological advances in such areas as meshed HVDC networks, HVDC protection & control, transformers, new-generation sensors and high-speed information transfer, energy storage, software, components, etc.

“Today, the institute is hosted primarily at the Alstom complex at Villeurbanne, France. However, we are in the process of building our own campus with buildings, equipment and test facilities. In fact, we envisage making our test facilities commercially available to
third parties. The same is true of the intellectual property (IP) we generate. We already have some patents in the pipeline and we shall leverage our IP assets to forge new partnerships and generate licence income.”

2__An R&D institute with an educational brief

One of the pre-requisites for establishing an Energy Transition Institute is to offer educational opportunities. This is an important

aspect of the SuperGrid Institute's mission. Hervé Morel, Senior Scientist at Université de Lyon is scientific consultant for the SuperGrid Institute's Programme 3 – power electronics. He explains its benefits for universities and their students. "For us academics, the SuperGrid Institute is a long-term project. Its mission is also very broad, with very ambitious technological goals. This contrasts with previous public-private initiatives, which have always been limited in scope. It therefore offers students much greater opportunities
and a broader spectrum of research areas.

"A key point for universities and students is the proximity of test and measurement facilities on high-power, high-voltage prototypes. Very few university labs have access to this type of equipment – anywhere in the world. These tests and measurements will then constitute the starting point for new basic research projects.
Some PhD research projects are currently under way. For example, a 'fail-to-short' project – a packaging technique to ensure that a failed electronic module is seen as a short circuit. Another is focusing on the control of high-voltage power electronics to ensure a high level of insulation."

3__Five programmes for green progress

Jean-François Ballet, Managing Director of the SuperGrid Institute and Vice-President Industry Projects at Alstom Grid, explains,
"We have structured the SuperGrid Institute into five key programmes to achieve our ambitious goals."

Programme 1: Supergrid system architecture, operation and control
Developing large DC grids raises a number of technical challenges: DC grid protection against electrical fault, DC voltage transformation, power flow controllability in a meshed system or in a system which involves LCC and VSC technologies, and more. Architecture principles must also allow the co-existence of technologies from different origins. Achieving the right technical performance of future DC grids or combined AC-DC power systems is only possible through simulation. This is because:

- DC grid stability involves much faster dynamics than AC grids, so precise electromagnetic transient simulation is required in which power electronics converter control systems need to be modelled accurately;

- real-time simulation is necessary to demonstrate system performance when integrating a new technology into the grid (for example a new protection scheme).Supergrid simulation in itself is a field for research and development.

Programme 2: Technologies for breaking, insulation and measurement
Programme 2 has the mission to prepare the technological building blocks for future substations. Its first challenge is circuit breaking on DC networks. This question is complex since the current does not pass through zero as in AC. To

overcome this problem it is crucial to design a new generation of circuit breakers that opposes a high enough voltage to that of the network to force the current to zero. Different short-circuit conditions and the time needed to eliminate the fault will demand optimised circuit breakers to reduce infrastructure costs.

The second challenge is the optimisation of gas-insulated substations for DC applications. Particular effort will be devoted to the use of solid insulation for DC as well as insulating materials that offer better performance and lower environmental impact. This includes the choice of new gas mixtures to replace SF_6.

The third focus area will be the principles of AC-breaking without SF_6. Designs using more environment-friendly products should be made available for 145 kV to 1,100 kV circuit breakers for short-circuit current up to 80 kA.

Programme 3: Power conversion technologies

Programme 3 is focused on power electronics technologies to meet the requirements of the future DC grid. Research covers innovative topologies and control to build highly efficient HVDC power converters – in particular for DC/DC conversion – that do not exist today.

Research projects include:

- medium-frequency transformers working at several kHz;
- new generation silicon carbide components to reach blocking voltages of 10 kV and higher;
- integration of transformers, power electronics and control to a very high level of voltage for the power converters.

Programme 4: Supergrid cables and lines

Programme 4 covers the development of specific

technological building blocks for cable systems and advanced materials, in particular for meshed HVDC networks. The specifics of meshed grids that could influence the requirements for materials and components of cable systems are:
- new types of power flow variation, transient modes and harmonics;
- new architecture configurations or iterative deployment (in particular offshore).

Hence the need to investigate:
- design optimisation and the development of new components;
- materials ageing;
- the development of advanced materials with improved performance.

Programme 5: Stabilisation and storage
Programme 5 aims at developing more grid flexibility with high capacitive storage. A special focus will be on developing a reversible pump turbine with improved performance:
- more responsiveness and stability during the start and stop of pumped and turbined sequences, to improve stocking or destocking electric energy;
- new turbo-machinery designs for a broader operational area, enabling off-design operation at low discharge flow;
- more operability with low or high head imposed by the plant site. The specifics of long-distance and meshed grids and the hydrologic and geographic conditions (continental and offshore) demand research into new combinations of head and discharge flow with high efficiency.

SuperGrid Institute Partners

INDUSTRIAL COMPANIES	PUBLIC LABORATORIES	UNIVERSITIES
ALSTOM	CNRS	INSA Lyon
Nexans	L2S	École Centrale Lyon
RTE Réseau de transport d'électricité	Ampère	Université Claude Bernard Lyon 1
VETTINER	Lyon	Grenoble INP
EDF	CREMHyG	Université Joseph Fourier
novasic	G2Elab	Supélec École Supérieure d'Électricité
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