SuperGrid Institute

Shaping power transmission

ANNUAL REPORT 2020

CONTENTS

EDITORIALS

Michel Augonnet,
SuperGrid Institute President

SuperGrid Institute successfully met several challenges in 2020. We secured the financial and professional commitment of our shareholders. We became ISO 9001:2015 certified, demonstrating our high-quality management capabilities and our ability to provide the services required by our shareholders and clients. Several new platforms were put into service over the course of the year. We paved the way for a very successful collaboration with the French transmission system operator RTE (Réseau de Transport d'Electricité) to develop a centre of excellence for direct current and power electronics. We laid the groundwork for important European projects such as Green Deal and LOLABAT, which has been awarded a Horizon 2020 program grant by the European Commission. All of these achievements confirmed our ability to stick to the ambitious plan we outlined in our previous Annual Report.

Of course, all this took place in the context of the COVID-19 crisis. Despite its challenges, we have been able to navigate the crisis effectively, a tribute to the people who make up the SuperGrid Institute team and also to our partners. Communications were more complicated given the requirements of working from home, and many staff sorely missed the ability to informally exchange with their colleagues on research topics. Nonetheless, we quickly put in place the tools needed to work collaboratively at a distance and we also ensured the physical barriers necessary to protect those who had to be present onsite. The fact that we were chosen to host the 22nd European Conference on Power Electronics and Applications (EPE'20 ECCE Europe), and could not do so in a live conference setting, was an opportunity we were sorry to miss. Nonetheless, we ran a successful online conference.

In a wider perspective, the crisis also brought opportunities. The importance of energy transition was clearly reaffirmed by the fact that during the lockdowns, people began to enjoy cities without cars, with cleaner air – they could measure the difference in their lives and environments.

For the Institute, this flagged the relevance of all the areas in which we work. The fact that network operators could not go out and do maintenance was also a driver for remote options, so that even with the temporary reduction in electrical consumption, there was an impetus for new services and equipment. Finally, the crisis has shown us that work at a distance is possible, and this has many implications for the long term – for the company, for society and for the environment.

SuperGrid Institute demonstrated its strengths as we faced – and met – all these challenges. We have fantastic test equipment and laboratories, of course, but essentially, we are a team made up of individuals from industry and academia who are motivated to work together, and who enjoy doing so. This is our biggest strength.

Today, we can definitely say that we are better known and that we are truly looked to as an industry leader. We have new and exciting partnerships and a unique position in Europe. We are preparing for our evaluation from the French High Council for Evaluation of Research and Higher Education (HCERES), which is important for us as an Institute. It is a means of demonstrating to the French State that we are fulfilling our purpose and mission: supporting industry development through technology and innovation. We will continue to expand abroad as well, and to develop our sales force.

In short, our message as we look back on 2020 is: 'We delivered.' Looking forward, we are confident that we will continue to grow in strength, capability and vision.

Hubert de la Grandière,
SuperGrid Institute Chief Executive Officer

“In 2020, we were thrilled to witness expressions of renewed confidence by our shareholders. The French State committed to support SuperGrid Institute over the coming four-year-period, until 2024, allocating a total of EUR 6 million more in subsidies than initially planned. All our other shareholders followed suit, confirming their commitments. In the context of the COVID-19 crisis, when many, if not all companies were looking for cash savings, this was a great display of support from shareholders and State alike.

We also received high scores from our clients: 9.4 out of 10 clients said they would recommend working with SuperGrid Institute.

For me, these are important achievements. They demonstrate how we are widening the reach of our activities, focusing not just on research, but also on customer service.

As planned, 2020 was a year of increased visibility, of opening up to the outside. We hosted the 22nd European Conference on Power Electronics and Applications (EPE'20 ECCE Europe) – the first time this event was hosted by an industry company. Yet equally important to me, we had the opportunity to demonstrate our technical capabilities by offering two webinars:

- a real-time demonstration of DC grid protection strategies in the context of PROMOTioN, and
- 'Unlocking HVDC interoperability: Exploring the options for future MTDC projects', which gave rise to very interesting exchanges on this high-stakes, ongoing issue.

On a similar note, 2020 was a year of heightened partnership at the French and European level. We won a Sea-GRID call for expressions of interest with OCTOPUS, one of five innovative projects selected for further development. In the process of responding to this call, we built a strong consortium that will continue to bear fruit in future offshore project bids. We also began a partnership with various transmission system operators and other major industry players to put together another European project. To me, it is a real vote of confidence that they have asked us to take the lead on the execution of the project if we win. This is not only a huge recognition of our competence, but also a sign of the trust invested in us.

In terms of infrastructure, we have a major investment underway in the form of a high power source for high voltage direct current (HVDC) short-circuit testing. This is our largest investment to date, and by the end of 2020, all of the equipment was in place. In order to ensure that our research is making the greatest impact possible, we have brought on board talented engineers whose job it is to liaise with industry actors and make sure our value proposition is aligned with market needs.

I must also mention ISO 9001:2015. Aside from what Michel has already signalled, the qualifying process represented a great tool for us. As an institute with new infrastructure, it helped us to plan maintenance, to structure our processes and to put in place a roadmap for continuing improvement.

Finally, I can't talk about SuperGrid Institute without talking about our people. We pride ourselves on the quality of our collective expertise. This quality was recognised when two of our PhD candidates were named PhD Student of the Year by the French Chapter of the IEEE Power and Energy Society. Congratulations!

All in all, 2020 was a year of confirmation and accomplishment for SuperGrid Institute.

There were challenges, of course, but we were able to meet them head-on and make sure that our excellence prevailed. I would like to thank our teams for their outstanding work, and for being particularly effective in managing the impact of COVID-19.

In 2021, we will continue to apply our excellence in research and development while fine-tuning our responsiveness to market needs. In this sense, 2021 promises to be rewarding, for us and for our clients. We look forward to confirming, once more, our place as a key player in collaborative innovation for the electrical power system of the future.”

WORKING TOGETHER FOR ENERGY TRANSITION

From left to right

Hubert de la Grandière, CEO

Amiel Kaplan, Training Programme Director & Communications Manager

Benoît Duretz, Sales & Marketing Director

Carole Guillaumin, Valorisation & Intellectual Property Director

Michel Augonnet, President

Renaud Guillaume, Programme Director – Power Storage & Balancing

Martin Henriksen, Programme Director – HVDC Cable Systems & Junctions

Charles Sarra, Maintenance, Quality, Safety & Environment Manager

Bruno Luscan, CTO & Programme Director – Supergrid Architecture & Systems

Alain Girodet, Programme Director – High Voltage Substation Equipment

Loïc Leclere, Programme Director – Power Electronics & Converters

Samuel Tiercelin, CFO

SuperGrid Institute's Management team

01 | AT A GLANCE

SUPERGRID INSTITUTE IS AT THE HEART OF ENERGY TRANSITION.

SUPERGRID INSTITUTE IS

a **leader** in supergrid technologies in Europe

a **complementary platform**
bringing together industrial & academic expertise and public research to collaborate on the development of electrical power systems

a team of **highly qualified experts**

a **trusted partner:** serious, internationally recognised, respected, established, solid

one of eight French Institutes for Energy Transition (ITE)

an initiative with a **unique business structure** and a **solid business plan**, backed by private and public shareholders

a **centre for innovation** comprising state-of-the-art facilities and test platforms

a **consulting platform** that places its expertise at the service of energy transition

an employer that takes **employee wellbeing** seriously

a **recognised authority**
in defining curricula for future electrical engineers

Dedicated to creating value from our expertise, testing facilities and intellectual property, SuperGrid Institute is driving research to meet market needs by developping technologies for the energy grid of the future.

HIGHLIGHTS IN 2020

FUNDING AND COMMITMENTS

Shareholders and the French State commit for **four more years** – until the end of 2024

France agrees to provide **€ 6 million more** in subsidies than initially planned

Auvergne-Rhône-Alpes Region **continues its support** with an ongoing grant

NEW COLLABORATIVE PROJECTS

OCTOPUS project wins Sea-GRID call for expressions of interest and is selected for the OceanDEMO project

LOLABAT project won

SiCRET and ARCHIVE projects started

INDIVIDUAL DISTINCTION

Piotr Dworakowski & Florian Errigo recognised at the French chapter IEEE Power and Energy Society (PES) PhD and Engineer of the Year awards

Michel Augonnet named President of CIGRE (International Council on Large Electric Systems)

PLATFORMS

All high power source short-circuit generator equipment installed

Long-term DC gas-insulated switchgear test bench
commissioned thanks to the PROMOTioN project

Pulse Electro-Acoustic Method test bench
commissioned for space charge measurements

Power converter medium frequency transformer platform
commissioned

HydroPHIL platform installed
the first dynamic hydraulic platform of its kind in Europe!

RESEARCH HIGHLIGHTS

Final contributions to the **EU PROMOTioN project** successfully delivered on meshed HVDC offshore transmission networks

Webinar on interoperability offered by SuperGrid Institute in collaboration with PROMOTioN

Advances made on the **Dynamic Virtual Admittance Control (DVAC) concept** with the conclusion of the RITSE project, part of the Grid2030 initiative

Promising results on cost-effective, reliable superconducting tapes demonstrated at the conclusion of the **EU FASTGRID project**

Innovative epoxy composite developed for HVAC and HVDC

Work started on financial forecasting for the energy industry as part of the **EU XFLEX HYDRO project**

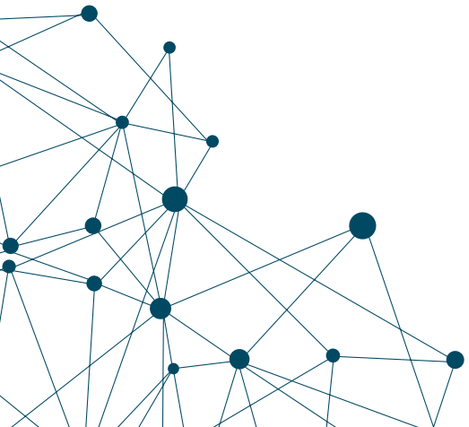
02 | SUPERGRID INSTITUTE: DEVELOPING THE ELECTRICITY NETWORKS OF THE FUTURE

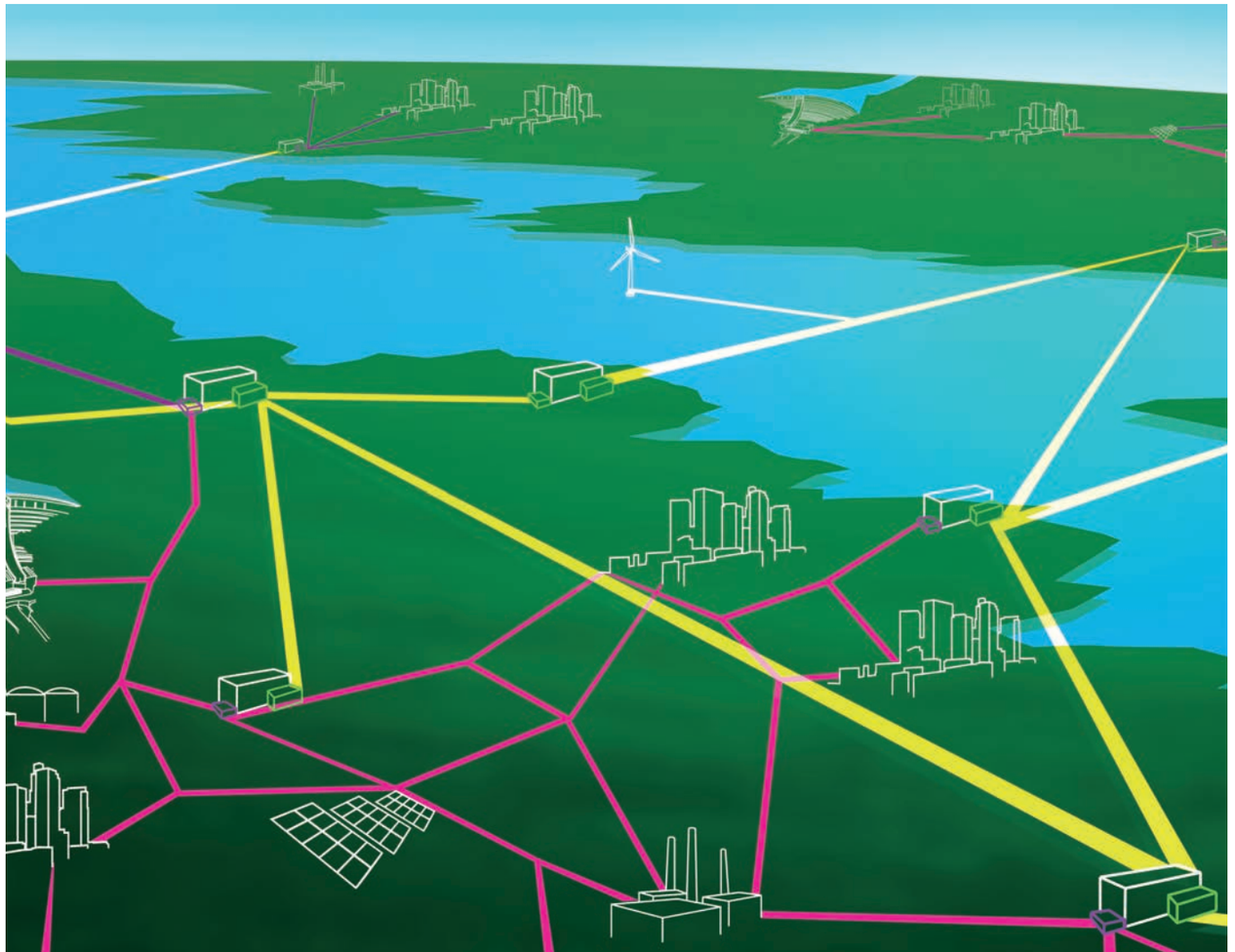
> “Our long-term ambition is to establish SuperGrid Institute as the leading European authority on supergrid technologies and a key player in collaborative innovation for the development of electrical power systems.”
>
> *Hubert de la Grandière, CEO*

At a time when it is increasingly important to lower our dependency on fossil fuels and reduce greenhouse gas emissions, SuperGrid Institute is delivering solutions for renewable energy integration that provide its customers and partners with a strong competitive advantage.

SuperGrid Institute's research and development is at the heart of energy transition. Its experts work to improve conventional energy networks and develop new, hybrid ones, increasing the use of rapidly evolving direct current (DC) technologies and managing them effectively. In this way, they increase the efficiency of integrating renewable energy into existing alternating current (AC) networks.

With an average annual budget of EUR 22 million, SuperGrid Institute is a key player in the field of direct current in Europe. It is one of eight French Institutes for Energy Transition (ITE), interdisciplinary innovation and research centres dedicated to researching new energy technologies. The institute employs 175 engineers, researchers and support staff of 29 different nationalities. With headquarters in Villeurbanne, near Lyon, and a site in Grenoble, SuperGrid Institute is supported by the French State, local authorities and a consortium of private and public shareholders that includes leading industrial as well as academic institutions.





WHAT IS SUPERGRID INSTITUTE?

SuperGrid Institute links industry expertise with public research within the framework of public-private co-investment and in a spirit of close collaboration. It is:

- a French Institute for Energy Transition (ITE)
- a research, consulting and test centre
- a collaborative platform for industrial expertise and public research
- an innovative initiative backed by private and public shareholders.

SuperGrid Institute offers a complete range of technologies and services in:

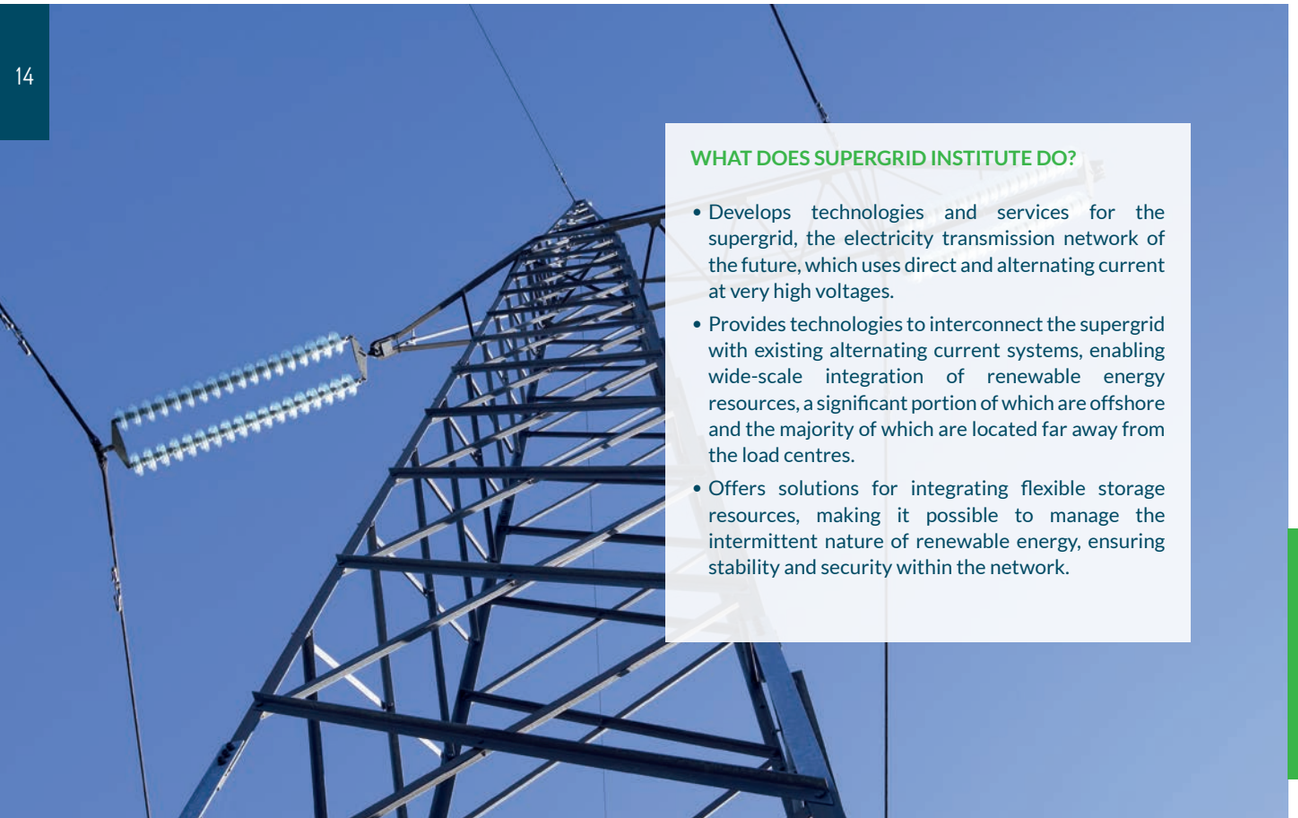
- applied research, innovation, licensing and technology transfer
- high-end test platforms
- expertise and consulting to identify technical needs, resolve technical challenges, identify areas for improvement and optimise solutions.

WHY A SUPERGRID?

Electricity is generally transmitted via grids at the national level, which carry the energy output of fossil fuel, nuclear and hydraulic power stations to the end user via distribution networks. A supergrid is a wide-area transmission network that connects to existing AC networks and renewable energy resources; it uses high-voltage direct current (HVDC) to enable the transport of large volumes of electricity over long distances, considerably reducing the losses incurred. The long-distance transmission lines balance out the network and contribute to its stability, also enabling interconnections between different countries. In addition, because DC cables are usually placed underground or submerged, they alleviate the building social pressure against overhead power lines.

WHY IS THIS IMPORTANT FOR RENEWABLE ENERGY?

Power stations were traditionally built as close as possible to the end users, usually between 50 and 100 km away. With the wide-scale integration of renewable energies of solar, wind or tidal origin – situated offshore or onshore – the distance between generation facilities and end consumers is significantly increased. Furthermore, renewable energy sources are intermittent because of their dependency on factors such as wind, sun etc. New technology coupled with flexible storage solutions make it possible to manage the intermittent nature of renewable energies, ensuring both the stability and security of the network.

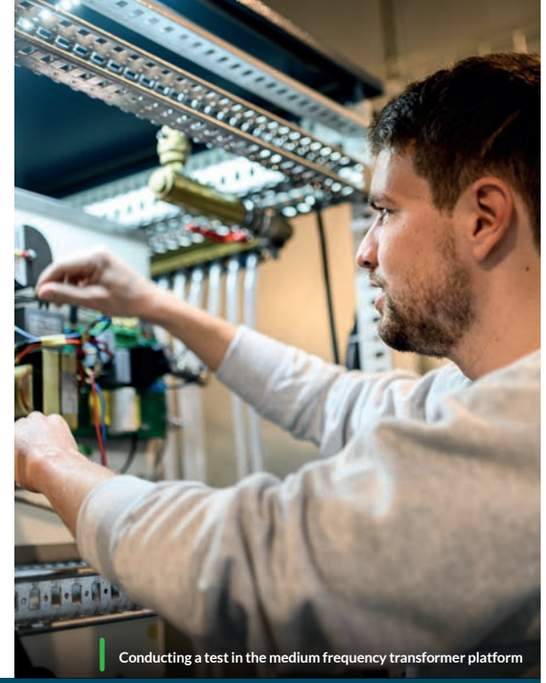


WHAT DOES SUPERGRID INSTITUTE DO?

- Develops technologies and services for the supergrid, the electricity transmission network of the future, which uses direct and alternating current at very high voltages.
- Provides technologies to interconnect the supergrid with existing alternating current systems, enabling wide-scale integration of renewable energy resources, a significant portion of which are offshore and the majority of which are located far away from the load centres.
- Offers solutions for integrating flexible storage resources, making it possible to manage the intermittent nature of renewable energy, ensuring stability and security within the network.

CREATING NETWORKS FOR A CLEANER FUTURE

Today there is a global focus on reducing dependence on fossil fuels and limiting greenhouse gas emissions. At the same time, the European Union requires each member country to be interconnected and able to export up to 15% of its production capacity to its neighbours by 2030. SuperGrid Institute's ultimate objective is to develop technologies for the electrical transmission grid of the future: a large-scale, cross-border network fully interconnecting the existing alternating current systems.



Conducting a test in the medium frequency transformer platform

THE FUTURE OF POWER TRANSMISSION

THE CHALLENGES

- Ensuring the reliability of the power supply.
- Integrating renewable energy resources.

SUPERGRID INSTITUTE'S VISION

To position itself as the European leader in the field of supergrid technologies, and as a key player in the development of the electric power system of the future.

SUPERGRID INSTITUTE'S MISSION

To support its clients in developing electric power systems by offering value-added technologies and services that enable them to transport energy from renewable resources on a large scale, guaranteeing efficiency while ensuring the stability and security of the network.

SUPERGRID INSTITUTE'S FOUR MAIN OBJECTIVES

1 | Develop and strengthen the sector.
2 | Break the technological barriers related to DC grids.
3 | Enrich its results through collaborations with industrial players.
4 | Nurture talent.

> "Collaborative projects are important to us at SuperGrid Institute. Increasingly, we are being recognised by our partners for our ability to lead, innovate, provide insights and deliver solutions in response to real market needs, in France and across Europe."
>
> *Paul Vinson, Head of Collaborative Projects*

Conductivity characterisation of up to 4 solid insulation material samples

INNOVATION & KNOWLEDGE TRANSFER

SuperGrid Institute's comprehensive scope sets it apart from other academic and industrial players. Its shareholder group brings together, in a collaborative spirit, industry and academia, as well as public and private companies. The Institute's unique working environment facilitates interaction, knowledge sharing and exchange among experts from diverse domains of research. Equipped with state-of-the-art test platforms and resources, they contribute to making France a champion of innovation in energy transition, creating value from their research.

> "This complex relationship works because everyone is aiming for common goals, in perfect harmony."
>
> *Michel Augonnet, President*

> "We design solutions that will be useful to everyone. We are increasingly focused on marketing the results of our research and development, creating value from our expertise, testing facilities and intellectual property."
>
> *Hubert de la Grandière, CEO*

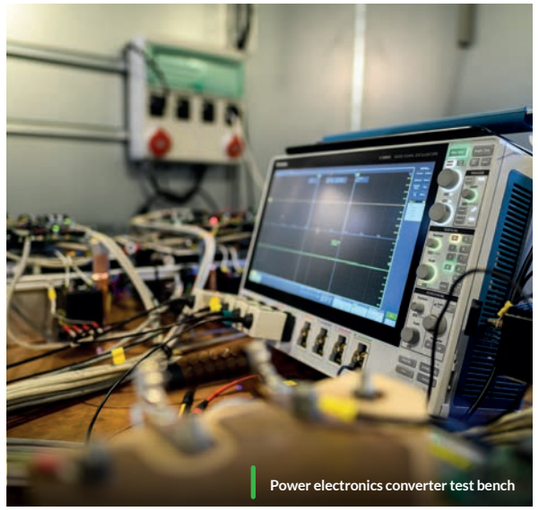

Technical courses available on the company's online platform

> "Our training programme aims to make HVDC and MVDC technologies and innovations accessible to all. SuperGrid Institute's collective knowledge and know-how drive our training offer."
>
> *Amiel Kaplan, Training Programme Director*

SUPPORTING THE SECTOR

SuperGrid Institute's unique environment for research acts as an incubator for innovation at the forefront of power grid technologies. The only privately run research centre in its domain in France, it provides thorough and personalised training solutions that benefit from its complete array of resources.

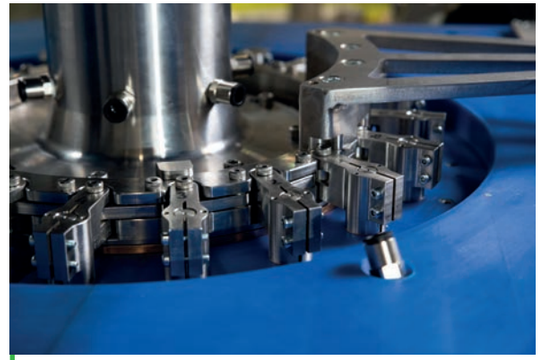
Understanding high voltage direct current (HVDC) supergrids is crucial for the future of the energy industry. SuperGrid Institute works to promote energy transition through education at every level, from secondary school to life-long learning. Its engineers work alongside PhD students and interns to carry out applied research that addresses industry needs. The company also supports educational institutions in developing their own training curricula on MVDC, HVDC and supergrid technologies.


Power electronics converter test bench

NEW PLATFORM: HYDROPHIL

The latest addition to SuperGrid Institute's array of test platforms, the HydroPHIL (Hydro-Power-Hardware-in-the-Loop) platform is unique in Europe. A scale model of a hydraulic storage plant operating in real time, HydroPHIL can simulate the performance of numerous technologies, from new algorithms of control systems to integrated technologies (for example for pump-turbine hybridisation). The platform also makes it possible to measure the impact of the tested technologies on the stability of the grid.

The platform includes a four-quadrant amplifier that drives the three phases of a synchronous generator, connected to a pump-turbine by a shaft. The pump-turbine is integrated in a hydraulic loop.



The four-quadrant amplifier makes it possible to emulate an electrical network, while the hydraulic loop permits the simulation of the network of penstocks in a real installation.

A controller regulates, as necessary, the degree of freedom of the model: the opening of the guide vanes, the excitation of the synchronous machine and its speed of rotation.

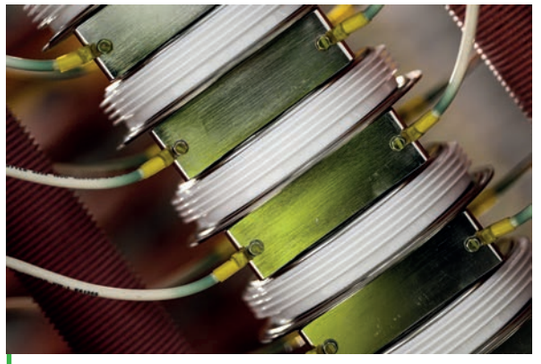
Covering 60 m² at SuperGrid Institute's Grenoble site, the platform is operated by one technician and one test engineer. It is expected to be fully operational in the spring of 2021.

High power source's excitation system – allowing the generator to maintain a steady frequency during high current short circuit tests.

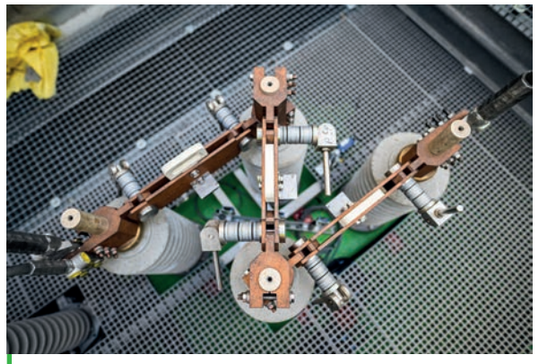
NEW PLATFORM: HIGH POWER SOURCE

Comprising 2 340 m² at the Villeurbanne site, this platform is designed to perform short-circuit testing on equipment at different frequencies (50 Hz, 60 Hz and 16,667 Hz) and at as much as 80 kA – or more than 150 kA when coupled with the generators of the CERDA Testing Laboratory, also in Villeurbanne. What makes it unique, however, is its ability to test high voltage direct current (HVDC) equipment under 170 kV DC and up to 40 kA. Fully operational in 2021, the platform will be remotely operated from the CERDA control room.

3 000 MVA short circuit generator able to provide short circuit current at several frequencies, from 10 Hz up to 60 Hz.



Detail of a high voltage 6-pulse diode rectifier allowing SuperGrid Institute to perform DC short circuit current tests up to 170 kV DC and 40 kÂ.



Detail of power transformers able to adapt test voltage from 6 kV up to 190 kV: connections of 6 kV secondary windings.


Technician working in the vacuum brazing platform

03 | KEY FIGURES

FINANCE

€1.9 M
turnover in 2020

€220 M
total **investment**

€22.8 M
annual budget

SUPPORTERS

6 **industrial** shareholders

1 public shareholder

7 **academic** shareholders

Supported by 3 public bodies


Dielectric material development platform

TEAMS

175
staff

29
nationalities

35
average age
of team members

FACILITIES

2
research sites

8 400 m²
of **laboratories** and **test platforms**

2 400 m²
of **offices**

19
test platforms

PROGRAMMES

5 research programmes

1 training programme

KNOWLEDGE

since 2014	In 2020
79 patent applications	**10** patent applications
38 theses defended	**8** theses defended
222 publications	**44** publications

Innovative monitoring equipment at the Grenoble site

04 | OUR SHAREHOLDERS & PARTNERS

LE GRAND PLAN D'INVESTISSEMENT

INDUSTRIAL SHAREHOLDERS

ALSTOM · EDF · GE Grid Solutions / GE Hydro France · Nexans · VEITNER

ACADEMIC SHAREHOLDERS

CentraleSupélec · CENTRALELYON · Grenoble INP · INSA · Université Claude Bernard Lyon 1 · UGA Université Grenoble Alpes · université PARIS-SACLAY

WITH THE SUPPORT OF

La Région Auvergne-Rhône-Alpes · GRANDLYON la métropole · ANR

PUBLIC SHAREHOLDER

BANQUE des TERRITOIRES

ADDITIONAL PARTNERS FEATURED IN THIS REPORT

ABB · ALPIQ · ALTER TECHNOLOGY · Ampère · ANDRITZ Hydro · CeramTec · CENTRALE NANTES · cnrs · CNR · CREMHyG · DGA · DNV·GL · EIU · EMOTORS · EPFL · edp · equinor · G2Elab · GeePS · gipsa-lab · Hochschule Kempten · ICMAB CSIC · institute IMDEA · imp · INESCTEC · eit InnoEnergy · IRT · KIT · KTH · KU LEUVEN · L2S · LAAS CNRS · Laplace · LaTEP · LIEBHERR · MITSUBISHI ELECTRIC Changes for the Better · NAVAL ENERGIES · nucletudes · OXOLUTIA · POLYTECHNIQUE MONTRÉAL · RED ELÉCTRICA DE ESPAÑA · RSE · Rte Le réseau de transport d'électricité · RWTH AACHEN UNIVERSITY · SAFRAN · SCiBreak · Scottish & Southern Electricity Networks · STU · TEL AVIV UNIVERSITY · TenneT · THEVA · TU Delft · TU Graz Graz University of Technology · UNIVERSITY of ABERDEEN · vtesco TECHNOLOGIES · VOITH

05 | MILESTONES

HVDC RECOGNISED AS HIGH PRIORITY

SuperGrid Institute presented its vision for the future of energy networks during a workshop at the European Commission's Directorate General for Energy in Brussels. The presentation by Bruno Luscan, SuperGrid Institute's Chief Technology Officer, emphasised the key role of HVDC, and in particular multi-terminal architectures (MTDC), in addressing power flow challenges and stability issues in the future network. The discussions confirmed that the topic of MTDC is now a high priority for the European Commission.

FEBRUARY

EXCELLENCE IN INNOVATION

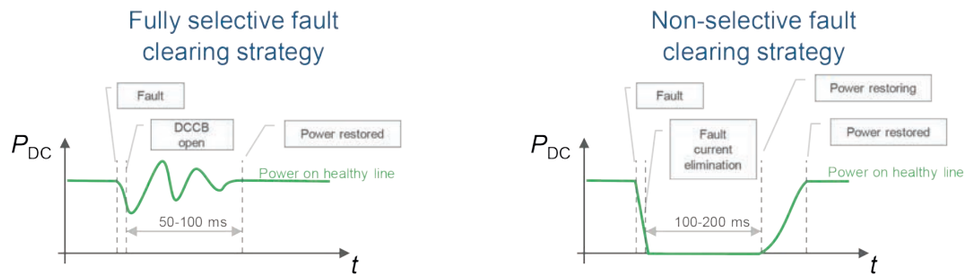
SuperGrid Institute, together with its fellow Institutes for Energy Transition (ITE), joined France's eight Technological Research Institutes (IRT) as members of the French Institutes of Technology (FIT) association. The FIT association aims to strengthen the attractiveness of the IRT and ITE model, with its structural and organisational diversity, both nationally and internationally, acting as 'champions of innovation for industrial and economic excellence'. It promotes local, regional and European-wide collaboration between industrial and academic players with the mission of driving French innovation so as to accelerate industrial and energy transition.

APRIL

TRUSTED PARTNER

SuperGrid Institute and TRACTEBEL Engineering jointly delivered a report on Technical requirements for connection to HVDC grids in the North Sea. By 2050, some 200GW of offshore wind energy is expected to be harnessed in the North Sea. This will require the construction of complex offshore grid structures, for which hybrid projects can reduce costs significantly. TRACTEBEL commissioned the study to SuperGrid Institute, inviting the company to perform technical analyses and simulations to facilitate the design of future DC grid extensions. The report contains several case studies and is available on the European Union Publications Office website.

TRACTEBEL ENGIE



Power restoration for full selective and non-selective fault clearing strategy

RECOGNISED EXPERTISE

SuperGrid Institute was asked to join the Advisory Board of the FlexPlan project, which aims to introduce new storage and flexibility resources in electricity transmission and distribution grids as an alternative to building new grid elements.

DISTINGUISHED AMONG PATENT APPLICANTS

For the second year running, SuperGrid Institute was among the top three small and medium enterprise patent applicants on the French National Institute of Intellectual Property's (INPI) list. For the first time, it was among the top 10 companies that had co-filed patent applications resulting from collaboration between industry and academia and/or public research. The significant number of patent applications produced by SuperGrid Institute – a large part of its value proposition – is particularly impressive for such a young company.

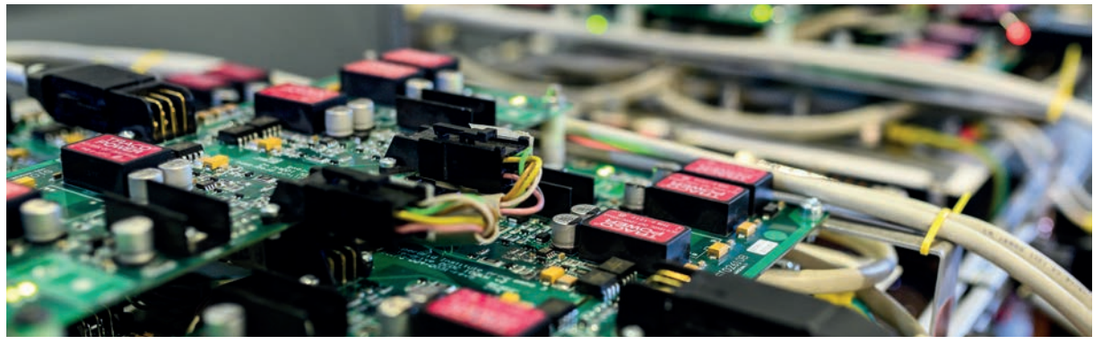
INTERNATIONAL ACKNOWLEDGEMENT

The International Smart Grid Action Network (ISGAN), an International Energy Agency (IEA) Technology Collaboration Programme (TCP), invited SuperGrid Institute to contribute to their discussion paper 'micro vs MEGA: trends influencing the development of the power system'. Several SuperGrid Institute team members joined with energy experts from across the globe to produce this paper which analyses the main trends shaping the development of future power grids. The Institute's main contributions were focused on the architecture of future transmission grids, the challenges involved in their control and maintaining their stability.

COMMITTED TO QUALITY

SuperGrid Institute was ISO 9001:2015 certified for 'performing electrical, mechanical and characterisation tests and consulting services' with its two very high voltage platforms and its hyberbaric test platform. This certification acts as proof of the high standards and the commitment of the company to providing the best possible customer experience for its clients.

AUGUST



INVESTED IN THE SCIENTIFIC COMMUNITY

In September, SuperGrid Institute acted as the Local Organising Committee for the 22nd European Conference on Power Electronics and Applications EPE'20 ECCE Europe – the first time a private company has played this role. The Conference General Chairman was Dr. Abdelkrim Benchaib, a prominent member of the SuperGrid Institute team. Due to the COVID-19 pandemic, the conference had to be moved online but it remained a remarkable event thanks to the efforts of the EPE Organising Committee and the Institute. Beyond its efforts to organise and chair the conference, SuperGrid Institute's contribution was significant: the company gave a keynote, presented 14 scientific papers, participated in one vendor session and chaired two industrial sessions.

SEPTEMBER

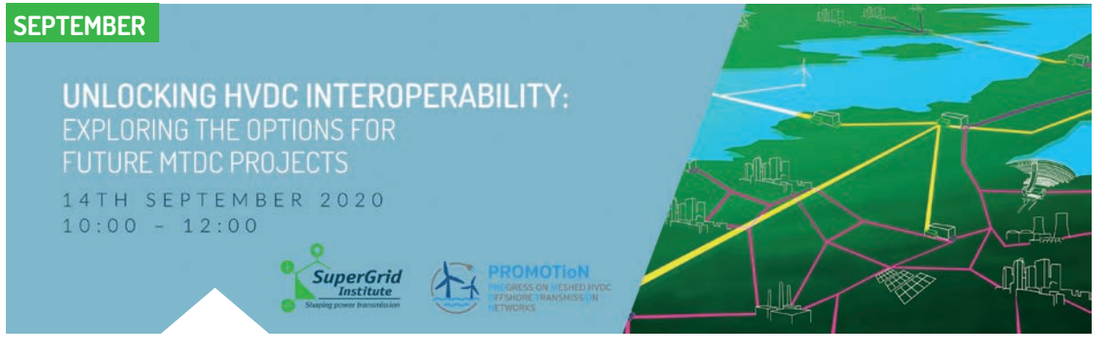
PROMOTION OF FUTURE DIRECTIONS

PROMOTioN, the largest energy project in the EU's Horizon 2020 research programme, was successfully concluded. SuperGrid Institute worked with 34 partners from 11 countries over the course of the 4.5 years of this project, studying the future of Europe's offshore energy grid. SuperGrid Institute made important contributions to several areas of the project: conducting real-time simulations of HVDC grids; demonstrating protection strategies for the offshore grid; designing a gas-insulated DC voltage source for long-term testing on gas-insulated switchgear (GIS); and evaluating the partial discharge characteristics of replacement gases, among others. With this project SuperGrid Institute has become recognised as an important player in the field of protection strategies.

SEPTEMBER

PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

SEPTEMBER



CONNECTING VIA WEBINAR ON INTEROPERABILITY

Also in September, SuperGrid Institute took advantage of its convening power to organise a webinar on a high-stakes issue within the energy industry: interoperability. Co-hosted by the PROMOTioN project, the webinar provided network operators and manufacturers the opportunity to explore diverse ways of moving forward on 'Unlocking HVDC interoperability: Exploring the options for system and equipment interoperability and for future MTDC projects.'

OCTOBER

Crédit Impôt Recherche CIR

TAX CREDIT FOR RESEARCH

SuperGrid Institute was granted 'Crédit d'impôt recherche' (CIR) status. This means that stakeholders and partners investing in research and development through the Institute via their French legal entities can benefit from a research tax credit.

NOVEMBER

WIDE COLLABORATION FOR OFFSHORE PROJECTS

The LISORE project, designed to explore technological bottlenecks and identify means of reducing the costs of offshore substations for commercial floating windfarm projects by 2025, was successfully completed. Piloted by France Energies Marines, a fellow ITE, the project brought SuperGrid Institute together with leading institutional and industrial partners, including RTE (France's transmission system operator), EDF, Naval Energies, Chantiers de l'Atlantique, Université de Nantes, INNOSEA, Siemens and Comex.

GROWING MEDIA INTEREST

After a first appearance on B SMART TV at the start of the year, Hubert de la Grandière, CEO of SuperGrid Institute, was invited back to be interviewed by the economics journalist Jean-Marc Sylvestre on the set of SMART PME. This second interview provided the opportunity to delve deeper into the ins and outs of the company, focusing on SuperGrid Institute's challenges and priorities, its clients and solutions, and how the company is driving the technological change needed to meet European energy transition targets.

DECEMBER

DECEMBER

VOTE OF CONFIDENCE

The French State renewed its contract with SuperGrid Institute, confirming the Institute's status as an Institute for Energy Transition (ITE). The new contract guarantees financial contributions for the next four years as part of the Investments for the Future programme: EUR 17 million in capital via France's Caisse des Dépôts et Consignations; and a subsidy of EUR 6 million to be paid out over 2021-2024 by the French National Research Agency (ANR). The contract formalises the French government's ongoing support of SuperGrid Institute, demonstrating the trust it places in the Institute as a driving force of innovation. In the context of France's industry and energy transition, it recognises SuperGrid Institute's contribution to developing the electricity grid of the future and integrating renewable energies on a massive scale.

06 | OUR BUSINESS: ADVANCING ENERGY TRANSITION

SuperGrid Institute, a world-class expert in high voltage direct current (HVDC) and medium voltage direct current (MVDC) systems and technologies, is actively contributing to energy transition by removing the technical barriers to the deployment of supergrids.

The company provides technologies and services for clients that include power producers, transmission system operators, distribution system operators, project integrators, project developers, product manufacturers, technology providers, power consumers, policy makers and consultants.

200% increase of orders received
(compared to 2019)

31% of orders came from non-shareholders
(compared to 19% in 2019)

94% of clients say they would recommend working with SuperGrid Institute

SUPERGRID INSTITUTE'S COMPLETE RANGE OF TECHNOLOGIES AND SERVICES CAN BE GROUPED INTO THREE MAIN AREAS:

INNOVATION AND TECHNOLOGY TRANSFER

Innovative technologies and their associated registered patents make for a win-win technology transfer process that includes:

- solutions based on our innovative applied research results
- assistance in developing results or technologies for the market
- licensing and technology transfer, including protection of intellectual property
- specific collaborations for applied research.

HIGH-END TEST PLATFORMS

Clients benefit from SuperGrid Institute's high-end test platforms:

- an AC/DC high voltage laboratory
- a dielectric material laboratory
- a real-time simulation platform
- a vacuum brazing platform and plasma chamber
- a power electronics characterisation and converter platform
- a medium frequency transformer laboratory
- a combined hyperbaric test laboratory
- a pump storage laboratory
- a cable testing platform.

Material characterisation using infrared spectroscopy

EXPERTISE AND CONSULTING SERVICES

The company's skills, industry experience, cutting-edge innovations and facilities constitute a valuable resource, enabling SuperGrid Institute to:

- conduct dedicated grid studies – including technical and economic assessment studies – for HVDC systems, MVDC systems, offshore windfarm and photovoltaic (PV) farm connection grids, among others
- resolve technical challenges and perform trouble shooting on clients' equipment thanks to the company's full range of technologies, tools and test platforms
- (co)develop, design, validate or improve, and performance-test new products, such as HV/MV equipment, converters, medium frequency and solid-state transformers, cable junctions and accessories.

Project meeting at Villeurbanne site

> "2020 was a pivotal year for SuperGrid Institute in terms of business development. We focused on being more receptive to market and client needs, and on making sure we offer relevant value propositions."
>
> *Benoît Duretz, Sales & Marketing Director*

A pivotal year

SuperGrid Institute headquarters, Villeurbanne

More than ever, stakeholders in the ecosystem are giving concrete signs of their recognition of the key role of multi-terminal, multi-vendor, HVDC in the grids of tomorrow. At the same time, SuperGrid Institute is increasingly seen as a leader on important collaborative, innovative projects, with the legitimacy to take on major responsibilities.

In 2020, SuperGrid Institute confirmed its readiness to respond to unexpected challenges effectively and efficiently. With the COVID-19 crisis, some of the company's clients felt the need, as in many sectors, to make adjustments regarding their decisions and investments. Furthermore, exchanges with potential clients were significantly curtailed by the cancellation of events and conferences worldwide. In this context, the company's management and teams adapted quickly and well, keeping in tune with the markets and staying as close as possible to clients. Despite the challenges, SuperGrid Institute managed to bring on board a significant number of new clients and signed numerous new orders. While maintaining the full confidence of its shareholders, the company received more and more business from clients who are not shareholders of the Institute, and this trend is expected to continue even more markedly in 2021. The number of offers made in 2020 more than doubled those made in 2019 and the same is true for purchase orders, building a robust business pipeline for 2021 and beyond. This demonstrates a good and very promising dynamic in business development for the coming years.

EXAMPLES OF ORDERS RECEIVED IN 2020

- Grid studies of offshore HVDC networks in the North Sea, for Tractebel Engineering.
- Collaboration with a major European transmission system operator to compare various architectures of offshore windfarm connection grids.
- Technical consulting services for TuNur Ltd, a renewable energy, storage and transmission developer.
- Training in HVDC and offshore windfarm connection architecture, for a major European transmission system operator.
- Modelling, simulation and short-circuit current calculation studies for a powerplant project in Guyana, with ELEKTEK.
- A study of potential solutions for the conversion of a pumping power station to variable speed, for EDF Hydro.
- Technical consulting services on HVDC materials for cable accessories, for a major worldwide manufacturer.
- Design, validation and testing of an MV interrupter for a major French railway equipment manufacturer.
- Design, manufacture and testing of a medium frequency transformer, for a major international group.
- Type tests on HV cables, for Nexans.

07 | RESEARCH PROGRAMMES & COLLABORATIVE PROJECTS

SuperGrid Institute benefits from the complementary strengths of each of its partners while developing its research programmes in total independence. Close collaborative relationships with industry players and academic institutions provide insights and innovative approaches, enabling the Institute's teams to overcome many technical challenges. Public-private joint investments and collaborative projects finance the work.

At the Villeurbanne and Grenoble sites, SuperGrid Institute's state-of-the-art research facilities, test platforms and laboratories are key to the success of its five research programmes, focused on medium and high voltage direct and alternating currents.

High voltage dielectric test platform: DC test capacity of up to 1200 kV, 20 mA

5 RESEARCH PROGRAMMES: 17 FEATURED RESEARCH PROJECTS

Dielectric material test & characterisation platform

SUPERGRID ARCHITECTURE & SYSTEMS

Bruno Luscan, Programme Director

"The Supergrid Architecture and Systems programme develops technologies to overcome the technical challenges facing direct current (DC) grids. In particular, it focuses on control and protection strategies for high voltage and medium voltage direct current (HVDC and MVDC) systems. This includes defining the requirements for the systems' key components and developing control systems capable of managing the stability of a DC network which need to be much more dynamic than those used in alternating current (AC) networks.

Designing and simulating the technical performance of future DC grids or combined AC-DC power systems is key to the programme's work. It carries out electromagnetic transient simulations with accurate, built-in models of power converter control systems and uses real-time simulation to demonstrate the system's performance when a new technology is integrated into the network (for example, a new protection strategy)."

HIGH VOLTAGE SUBSTATION EQUIPMENT

Alain Girodet, Programme Director

"The High Voltage Substation Equipment research programme develops substation technologies that respond to the constraints of future DC networks as well as those of current AC networks. It explores ways of clearing fault currents from meshed DC networks using circuit breakers, in addition to developing interconnection nodes to transfer energy.

Gas-insulated switchgear is essential to networks, yet it is currently highly dependent on sulfur hexafluoride gas (SF_6) as the insulating medium, declared at the top of the list of greenhouse gasses. The programme works to understand, model and optimise alternative solutions for gas-insulated switchgear. It also works on researching and implementing new solid and gas insulation systems that provide enhanced electrical performance and resilience while maintaining a low environmental impact."

Hyperbaric rig for testing subsea equipment up to 40 bars

POWER ELECTRONICS & CONVERTERS

Loïc Leclere, Programme Director

"The Power Electronics and Converters programme develops innovative power conversion solutions for HVDC and MVDC applications. In the field of HVDC it focuses on solutions for electricity transmission networks and covers AC/DC and DC/DC converters, large buffer storage systems and power flow controllers, while in MVDC it studies and develops technologies for distribution networks with a focus on protection, DC/DC converters and energy storage systems. The programme conducts research on topologies and controls for the power converters and their associated technologies such as medium frequency transformers, silicon carbide (SiC) components and switching cells. Other research topics include condition health monitoring and digital twin modelling applied to power converters.

The programme has advanced testing facilities to perform full characterisation tests (dynamic, static, reliability and robustness) on few kVolts and few kAmps power electronics components and back-to-back converter testing with a 100 kW deionised water cooling heat exchanger."

HVDC CABLE SYSTEMS & JUNCTIONS

Martin Henriksen, Programme Director

"The HVDC Cable Systems and Junctions programme develops solutions for insulation materials subject to the constraints of HVDC. By studying the behaviour of insulating materials when subjected to high dielectric stress, the programme develops high-performance materials, for use in electrical equipment or in components of HVDC cable systems. It models converters and cable systems in order to design tests that can be used to reproduce new types of transient modes and harmonics, and develops innovative methods and sensors for cable monitoring based on its analysis of the physical phenomena that cause ageing in insulation materials. The Institute's combined high voltage and hyperbaric test platform allows the programme to perform tests on subsea equipment in a controlled environment and develop new technological building blocks for subsea high-voltage cable systems."

POWER STORAGE & BALANCING

Renaud Guillaume, Programme Director

"The Power Storage and Balancing programme provides new ancillary services by adapting and developing hydraulic storage technology to support the integration of renewable energies within the European electricity network, based on the use of pumped storage plant (PSP) technology.

Wind and solar energy are highly variable so in order to use them on a wide scale, massive and reactive means of storage are needed. Although hydraulic storage is a mature technology – today it represents 97% of electrical energy storage worldwide – it will need to be greatly adapted to meet the challenges of energy transition. This programme focuses on the technological aspects of adapting conventional or variable speed pump turbines and improving their hydraulic characteristics. It also studies the hybridisation of PSPs with other means of storage and works on the economics of ancillary services."

PROMOTioN (PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS): **HIL DEMONSTRATION OF HVDC GRID PROTECTION SYSTEMS**

Interoperability, primary and back-up protection in non-selective fault-clearing strategies for meshed HVDC grids.

Duration: 2 years / Launched: 2018

Objectives

Demonstrate protection system performance using hardware in the loop (HIL) real-time testing, including:

- Primary and back-up protection sequences,
- DC grid restoration performance following the protection process,
- Equipment interoperability.

Scientific and technical scope

- Integrate intelligent electronic devices (IED), protection algorithms and DC circuit breaker models into real-time simulation environments.
- Develop DC grid benchmark models and test procedures for testing protection systems.
- Demonstrate equipment interoperability by implementing IEC 61850 communication protocols for protection relays.
- Develop a DC grid control for HVDC grid start-up and restoration.

Accomplishments in 2020

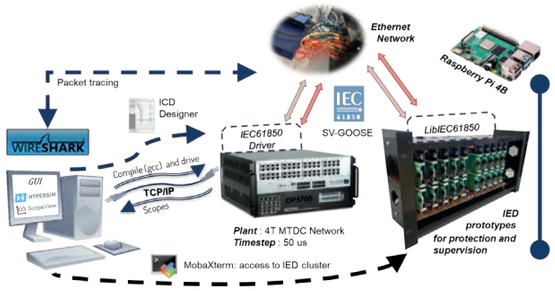
- Protection and supervision IEDs tested.
- HVDC breaker and MMC models integrated into the real-time simulation model.
- Primary and backup sequences validated on 4-terminal HVDC networks.
- Designed the communication architecture using IEC61850 and integrated it into the real-time model and IEDs.
- DC grid control designed, implemented and tested.

Major milestones

- Report: Hardware-in-the-Loop test environment and guidelines for demonstrating non-selective protection systems for meshed HVDC grids. Deliverable 9.5 PROMOTioN.
- Final HIL Demonstration of HVDC Grid Protection Systems Deliverable 9.6.
- Industrial session EPE'20 ECCE Europe "Hardware-in-the-Loop demonstration of non-selective protection systems for meshed HVDC networks".

Value for energy transition

During this project, SuperGrid Institute developed effective, robust protection systems for meshed offshore HVDC grids and increased their technology readiness level; bringing us one step closer to ensuring the reliable dispatch of offshore wind energy.



Hardware-in-the-loop test setup for HVDC network control and protection equipment

Project partners

ABB · DNV·GL · equinor · KTH · KU LEUVEN · MITSUBISHI ELECTRIC Changes for the Better · RWTH AACHEN UNIVERSITY · SCiBreak · Scottish & Southern Electricity Networks TRANSMISSION · TU Delft · UNIVERSITY OF ABERDEEN

RITSE (REDUCED INERTIA TRANSIENT STABILITY ENHANCEMENT)

Improve the transient stability of AC networks using batteries (BATTERTIA) and HVDC links (DVAC).

Grid 2030 · Innovating tomorrow's grid today

Duration: 2 years / Launched: 2019

Objectives

Dynamic Virtual Admittance Control (DVAC) calculates supplementary active power references of embedded HVDC links to enhance the surrounding system's stability thanks to the rapid response capabilities of HVDC. In the RITSE project, SuperGrid Institute aims to:

- Complete a transient stability assessment of the DVAC concept within a realistic network environment and validate the solution.
- Package the DVAC concept and demonstrate its relevance and utility for the grid.

Scientific and technical scope

Explore the use of new technologies (DVAC and BATTERTIA) to enhance transient stability in the power network by:

- Assessing the technologies' performance using offline & HIL simulations.
- Providing technical specifications to highlight the need for such technologies.
- Developing a Go-to-Market strategy.

Accomplishments in 2020

- Defined the technical specifications related to transient stability based on the grid code.
- Elaborated the drivers & value chain and built a strategy to break into the market.
- Proposed a new control structure for line tripping & generation loss and demonstrated defined cases using PSS/E.
- Implemented, tested and validated the DVAC in industrial hardware.

Diagram of the France-Spain interconnection (Source: ENTSO-E SG SPD REPORT 13.07.2017)

Major milestones

- PhD Juan-Carlos GONZALEZ "Transient stability of high voltage AC-DC electric transmission systems".
- Rotor angle stability enhancement using dynamic control of embedded HVDC links, J-C. Gonzalez, EPRI 2019 HVDC & FACTS.
- See the relevant publications on page 70.

Value for energy transition

The two concepts developed as part of the RITSE project (DVAC - SuperGrid Institute and BATTERTIA - IMDEA) will undoubtedly contribute to the increase of renewable energies in the grid by helping to increase the stability margins of low inertia networks.

Project partners

institute IMDEA · eit InnoEnergy · RED ELÉCTRICA DE ESPAÑA

VSC-BASED DC GRID INSULATION COORDINATION

Overvoltage protection for voltage-source converter (VSC) HVDC systems and DC overhead lines (OHL) & cables.

Duration: 4 years / Launched: 2017

Objectives

- Respond to the lack of insulation coordination procedures for VSC-HVDC systems.
- Propose a methodology for performing insulation coordination studies and offer design solutions that improve the reliability and operation of HVDC-OHL.
- Define guidelines and recommendations for an overvoltage protection strategy for VSC-HVDC systems.
- Support standardisation activities.

Scientific and technical scope

- Benchmark existing insulation coordination standards & solutions in AC systems.
- Identify & understand the major influential factors of HVDC systems compared to AC systems.
- Develop expertise for performing insulation coordination studies.
- Suggest insulation coordination procedures for modular multilevel converter based HVDC systems.
- Evaluate lightning indicators and propose design solutions to improve the performance of HVDC OHL when struck by lightning.

Accomplishments in 2020

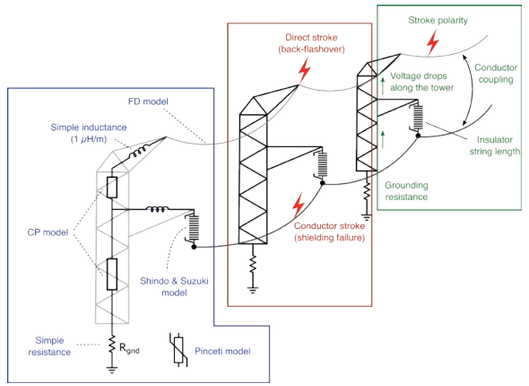
- Developed an in-house insulation coordination tool to support further studies.
- Produced a guide on insulation coordination methodologies & procedures.
- Proposed a configuration for overvoltage protection devices and designed the associated surge arresters for a project on connecting a photovoltaic farm.

Major milestones

- PhD Nicolas MANDULEY "Contribution to Insulation Coordination Studies for VSC-HVDC Systems"
- See the related publications on page 70.

Value for energy transition

Although insulation coordination is well understood within AC systems, there is a lack of understanding and standards on this topic for VSC-DC systems (crucial systems for integrating renewable energy on a massive scale). This project is reducing this knowledge gap by proposing new methodologies & procedures for insulation coordination in VSC-DC systems; paving the way for more reliable designs and reduced overall risk within the grid during normal and degraded operation.



Phenomena, events and models for the study of lightning impact on a high voltage OHL

Project partners

Working in collaboration with

Graz University of Technology

HVDC GRID PROTECTION STRATEGY FOR HYBRID NETWORKS

Cost-efficient HVDC grid protection strategy for networks combining cables and overhead lines.

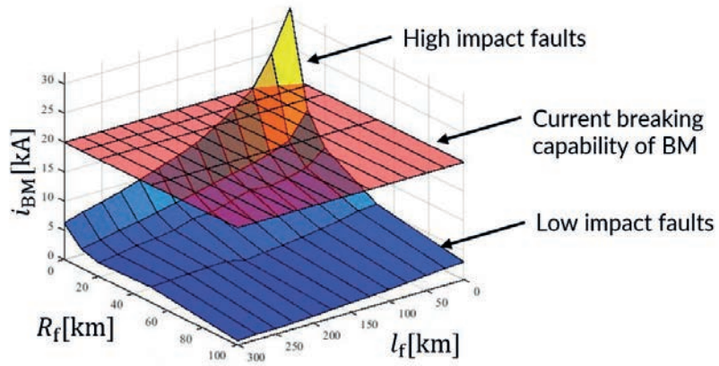
Duration: 3 years / Launched: 2018

Objectives

- Identify and develop a new protection strategy, and its associated fault identification algorithms, for a DC grid composed of both overhead lines (OHL) and cables.
- Reduce the frequency of power flow interruptions in the grid compared to a non-selective strategy.
- Ease the constraints on circuit breakers and DC limiting reactors within the HVDC grid.

Scientific and technical scope

- Investigate protection constraints related to faults on OHL through EMT simulations.
- Analyse fault currents in the DC grid using a semi-analytical fault current calculation method.
- Design protection components and algorithms adapted to the particularities of hybrid HVDC grids.



Current to be cleared by the line breaker module within 15 ms as a function of fault distance and resistance

Accomplishments in 2020

- Developed a new fault clearing strategy compliant with hybrid DC grids; the "Severity adapted fault clearing strategy".
- Created an optimisation algorithm for designing DC limiting reactors.
- Designed an innovative pre-energisation method for reclosing OHLs after a temporary fault.

Major milestones

- PhD Pascal TORWELLE "Development of an HVDC grid protection strategy based on hybrid overhead and cable lines".
- Patent pending FR2008296 "A method to re-energize an OHL or cable by using the internal energy of the capacitor of a mechanical breaker".
- Patent pending FR2006522 "Semi-selective protection strategy for hybrid OHL and cable MTDC system".
- See relevant publications on page 70.

Value for energy transition

HVDC systems offer a viable solution for transporting renewable energy from far-off locations. A more cost-effective and attractive solution to installing new cable lines is to convert existing AC OHL corridors into DC lines. This project aims to develop an effective protection solution for DC OHL, thereby unlocking one of the main challenges facing the integration of DC systems.

Project partners

CONNECTION SOLUTIONS FOR OFFSHORE WIND FARMS

Comparison of different connection solutions for offshore wind farms.

Duration: 1 years / Launched: 2020

Objectives

The project aims to assess and compare different technological solutions to connect offshore wind farms to shore by considering existing, proven technologies such as MVAC collection & HVAC export or MVAC collection & HVDC export as well as innovative technological solutions (MVDC collection & HVDC export, MVDC to shore using superconducting cables, MVAC to shore using superconducting cables). The solutions' feasibility is assessed, the main technical limitations identified and the costs estimated. Relevant key performance indicators (KPI) are defined and quantified for comparison purposes.

Scientific and technical scope

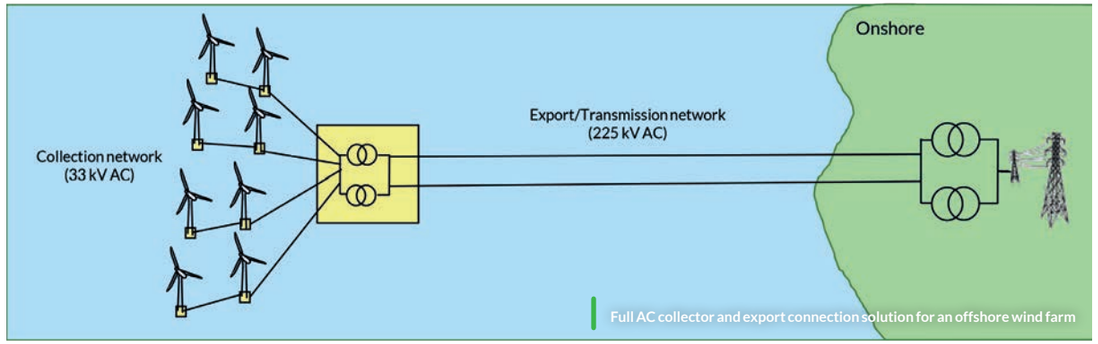
- Conduct a feasibility analysis from the operation, protection and black-start perspectives & identify the main technical limitations.
- Design the main components of the wind farm connection grid (collector and export sides) and define their specifications.
- Calculate the annualised costs based on CAPEX and OPEX indicators.
- Compare the proposed architectures to identify the optimum solution given the wind farm's generation capacity and distance to shore.

Accomplishments in 2020

- Defined the general methodology and relevant KPIs for assessing and comparing the solutions.
- Assessed two connection architecture solutions (MVAC collection & HVAC export and MVAC collection & HVDC export).

Value for energy transition

Offshore wind power plays an important role in the transition towards low-carbon energy. Many high-potential wind energy areas have already been identified with distances to shore varying from tens of km to hundreds of km. Finding the most cost-efficient technology to connect wind farms to shore is a key element for reducing wind energy costs and boosting offshore wind farm development. This project aims to find the best possible connection architecture for wind farms according to their generation capacity and distance to shore.



Full AC collector and export connection solution for an offshore wind farm

Project partners

DC CIRCUIT BREAKER

Protection equipment for high voltage direct current networks.

Duration: 6 years / Launched: 2018

Objectives

Develop a circuit breaker for multi-terminal DC networks making it possible to interrupt a fault current of 20 kA in less than 10 milliseconds.

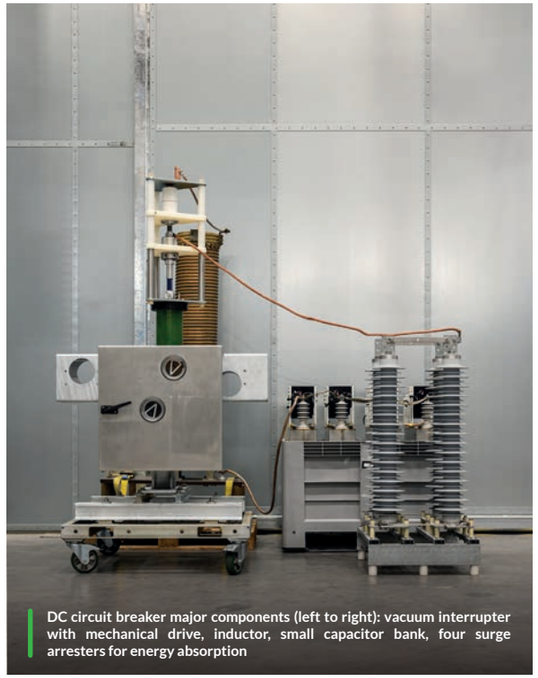
Scientific and technical scope

- Characterise the high current, high frequency breaking arc.
- Study the withstand of the transient interruption voltage by a metallic plasma in a vacuum.
- Optimise the fault clearing time.
- Develop fast switchgear actuators.

Accomplishments in 2020

- Optimal conditions for high frequency interruption identified.
- Demonstration of high current forced commutation for high voltage interruption.
- Demonstration of the actuator principle.

Closing the circuit of the auxiliary branch at the capacitor



DC circuit breaker major components (left to right): vacuum interrupter with mechanical drive, inductor, small capacitor bank, four surge arresters for energy absorption

Major milestones

- Patent pending: FR1874217 - High-voltage direct current cut-off device with an adaptive oscillation circuit and control method.
- Patent pending: FR1903008 - High-voltage direct current cut-off device with resonator and switching.

Value for energy transition

One of the technical barriers facing Multi-Terminal Direct Current (MTDC) networks is the ability to isolate faults within the grid. These networks will facilitate the large-scale integration of renewable energies, notably offshore energy. In addition to addressing the issue of isolating faults on MTDC networks, this circuit breaker provides an alternative to SF_6 or CO_2 as an arc quenching medium, making it more environmentally friendly than existing solutions.

Project partners

PARTIAL DISCHARGE MEASUREMENT SYSTEM

DC gas insulated substations (GIS) filled with an SF_6 substitute gas.

Duration: 1,5 years / Launched: 2018

Objectives

Evaluate the performance of partial discharge sensors under DC voltage with SF_6 gas and alternative gases.

Scientific and technical scope

- Analyse short and long term partial discharge behaviour under DC voltage, with different faults and gases (SF_6 and alternative gases).
- Develop monitoring and diagnostic methods for HVDC GIS equipment.
- Evaluate the performance of SF_6 gas alternatives.
- Use long-term testing, monitoring, and diagnosis to improve models and understand failure modes.

DC gas insulated switchgear test platform

Accomplishments in 2020

Obtained experimental results on long-term partial discharge behaviour under DC voltage with the following parameters:

- SF_6 and SF_6 alternative (FN-CO_2 mixture, FK-Air mixture) gases with different pressures;
- Two kinds of defects: a protrusion and a metallic particle on the insulator surface;
- Different measuring systems: conventional method, direct partial discharge pulse current measurement, UHF and magnetic sensors.

Major milestones

- Deliverable 15.8: Report on long term monitoring of DC GIS in presence of defects.
- PROMOTioN final conference | Breakout session 1: "Offshore HVDC Grid Technology: Alternative gases for future SF_6 free HVDC GIS – focus on PD behaviour and detection".
- Final WP15 workshop - Part 3: "Diagnostics and SF_6 Alternatives: Alternatives gases for future SF_6 free HVDC GIS – focus on PD behaviour and detection".
- See the related publications on pages 70 & 71.

Value for energy transition

Replacing the SF_6 in DC GIS is an important step in rendering HV switchgear more environmentally friendly. Testing the behaviour & electrical performance of SF_6 alternatives in the presence of defects makes it possible to minimise the risk of electric arcing and increase the technology readiness level of new protection technologies for HVDC grids.

Project partners

ABB · DNV·GL · TenneT · TU Delft · Scottish & Southern Electricity Networks Transmission

COST-EFFECTIVE FCL USING ADVANCED SUPERCONDUCTING TAPES FOR HVDC GRIDS

Protection strategy for multi-terminal DC grids, associating resistive superconducting fault current limiters (RSFCL) and mechanical circuit breakers.

Duration: 4 years / Launched: 2017

Objectives

- Significantly reduce the cost of the RSFCL.
- Propose a reliable RSFCL design for high voltage.
- Define the optimum solution, technologically & financially, for combining a RSFCL with a circuit breaker (CB).

Scientific and technical scope

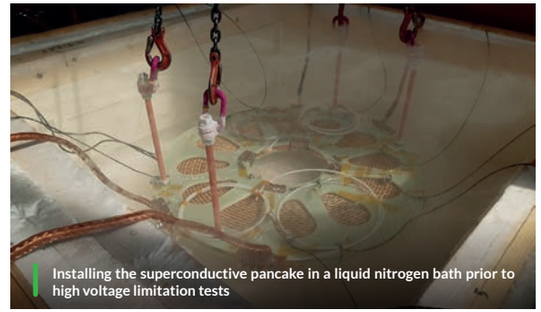
- Develop a structure for the conductor with significantly improved electrical properties in order to drastically reduce the RSFCL's cost, and produce it on an industrial scale.
- Study the dielectric properties of nitrogen in its liquid and two-phase form and propose design rules for high voltage.
- Design and produce pancake coils and the RSFCL.
- Propose methods for testing the RSFCL and CB in high voltage.
- Assess the cost of the RSFCL + CB solution.

Accomplishments in 2020

- Manufacturing and winding two 5 kV DC pancake coils.
- DC limitation tests of two pancake coils at more than 130 V/m.
- CAPEX evaluation of the RSFCL + CB solution.

Major milestones

- Techno Economic Analysis of HVDC limiter, FASTGRID Deliverable D5.3.
- Report summarising the dielectric and high current tests performed on the HVDC SCFCL smart module developed by FASTGRID project, FASTGRID Deliverable D4.6.
- Report on coil performance, FASTGRID Deliverable D3.3.
- HVDC breaker specification and prototype mechanical characteristics, FASTGRID Deliverable D3.4.
- Advances of the EC project FASTGRID, FASTGRID presentation at ASC2020.



Installing the superconductive pancake in a liquid nitrogen bath prior to high voltage limitation tests

Value for energy transition

The RSFCL + CB solution offers a cost-effective, reliable design for high voltage networks. By addressing fault current management, one of the technical barriers facing multi-terminal networks, this solution is helping to facilitate the large-scale integration of renewable energies into the grid.

Project partners

cnrs · G2Elab · ELU · EPFL · ICMAB CSIC · KIT · OXOLUTIA · Polytechnique Montréal · RSE · STU · Tel Aviv University · THEVA

INSULATION WITH C_4F_7N/CO_2 MIXTURE

Defining dielectric design criteria for epoxy insulators in Gas Insulated Substations using a C_4F_7N/CO_2 mixture.

Duration: 4 years / Launched: 2017

Objectives

The C_4F_7N/CO_2 mixture is one of the SF_6 substitute gases that can be used in high voltage apparatus however the interactions between this mixture and an epoxy solid insulator are not clearly understood. The aim of this project is to study the discharge behaviour along the epoxy insulators submerged in a C_4F_7N/CO_2 mixture in comparison to SF_6.

Scientific and technical scope

- Compare the radial discharge behaviour on epoxy discs when in contact with the C_4F_7N/CO_2 mixture compared to SF_6.
- Compare the tangent discharge behaviour on epoxy cylinders when in contact with the C_4F_7N/CO_2 mixture compared to SF_6.
- Measure flashover voltages under various experimental conditions; particle pollution on the surface, under lightning impulse and using alternative voltage.

Accomplishments in 2020

- Breakdown tests in SuperGrid Institute's high voltage test laboratory to define the withstand criteria.

Major milestones

- ISH2019: Characteristics of creeping discharges along epoxy surface in fluoronitrile/CO_2 gas mixture under lightning impulse.
- PhD Antoine PEREZ "Study of arc development mechanisms over solid insulators surface in CO_2/fluoronitrile gas mixtures".

Breakdown mock-up and test setup in SuperGrid Institute's high voltage laboratory

Value for energy transition

Due to the harmful effects of SF_6, manufacturers are increasingly looking for eco-friendly alternative solutions. One possible replacement gas is fluoronitrile (C_4F_7N) mixed with CO_2 but in order to correctly use this new mixture in a GIS, it is important to understand its dielectric behaviour at the interface with the solid epoxy insulators used in the substations. The tests carried out in this project show that the C_4F_7N/CO_2 mixture is a suitable alternative to SF_6, creating a valuable tool for reducing the carbon footprint of high voltage network equipment.

Project partners

LARGE LINEAR PV MVDC SYSTEM

Linear photovoltaic power plant project on the banks of the River Rhône (France).

Duration: 2 years / Launched: 2019

Objectives

Complete a feasibility study for the project and confirm the appeal of using a medium voltage direct current (MVDC) electrical architecture to transport solar energy produced over long distances of around 20 kilometres.

Scientific and technical scope

- Design an MVDC network architecture that facilitates the efficient transport of energy produced by photovoltaic panels to the AC mains network.
- Develop control and protection principles for the MVDC network.
- Study energy conversion solutions and MVDC network equipment (cabling & switchgear).
- Study the integration of energy storage into the MVDC network.
- Complete a techno-economic study of the solution.

Accomplishments in 2020

- Defined the MVDC network architecture & ratings.
- Developed simulation models which make it possible to define the main MVDC network equipment's sizing.
- Completed an in-depth feasibility study of the MVDC network equipment: MVDC cables & switchgear, AC-DC converter and transformer, DC-DC converters including medium frequency transformers & SiC power semiconductors.
- Carried out an industrial feasibility study in collaboration with manufacturers.

Major milestones

- Study specifications.
- Study of the electrical architecture & functional analysis.
- Electrical studies, technical specifications & interfaces.
- Project presented by the Compagnie Nationale du Rhône (CNR) during the Industrial Forum on "Novel power electronics technologies in power systems and transportation" EPE'20 ECCE Europe.

Value for energy transition

This ambitious project developed by the CNR, in collaboration with SuperGrid Institute and CEA, aims to maximise the capacity for renewable energy production in France by making use of linear terrain. The proposed architectural solution uses MVDC to reduce losses when transporting the energy produced over long distances.

Project partners

THERMOSIPHON: DIPHASIC COOLING SYSTEM FOR POWER ELECTRONICS

A passive, electrically insulated cooling solution for HV & MV converters.

Duration: 4 years / Launched: 2016

Objectives

Develop a passive cooling thermosiphon demonstrator with the following features:

- Able to cool 2.5 kW with > 5 W/cm² power density.
- Insulation able to withstand 100 kV DC.
- Cooling fluid with a low environmental impact.

Scientific and technical scope

- Analyse and choose the cooling solution and fluid.
- Define the cooling system's size.
- Manufacture the demonstrator.
- Characterise the demonstrator's operation at various loads and ambient temperatures.
- Model the cooling behaviour.

Thermosiphon demonstrator concept, including evaporator, condenser and tank

Accomplishments in 2020

- Construction of an operational demonstrator:
  - Cooling results achieved at ambient temperatures of 25 & 40°C up to 2.5kW.
  - Quantified diphasic heat exchange coefficients for various surface textures.
- Carried out a comparison with water cooling solutions.
- Implemented a diphasic thermosiphon thermal model.
- Defined design rules and possible improvements.

Major milestones

- Ph.D Majededdine Moustaid: "Développement expérimental d'un thermosiphon pour la régulation thermique de dispositifs d'électronique de puissance".
- See the relevant publications on pages 71 & 72.

Value for energy transition

This proposed cooling solution offers a passive alternative to pump-based devices, thereby increasing the converter system's overall robustness. The thermosiphon's environmental impact is low thanks to its choice of climate-friendly cooling fluid.

Completed thermosiphon demonstrator, including evaporator, condenser and tank

Project partners

ALSTOM · Ampère · EDF · GE · LaTEP

ARCHIVE (ARCHITECTURED CERAMIC FOR HIGH VOLTAGE POWER ELECTRONICS)

Power electronics module technology for 20 kV semiconductor devices.

Duration: 3 years / Launched: 2019

Objectives

The ARCHIVE project aims to demonstrate a breakthrough innovation for power electronics module technologies by enabling the use of SiC components up to 20 kV thanks to the introduction of an advanced ceramic substrate:

- With an innovative cooling approach which distributes the electrical insulation between the ceramic and the cooling fluid.
- With specific features on the metallised surface designed to limit the electrical field reinforcement observed in standard substrates.

Scientific and technical scope

- Define the specifications of the module demonstrator: size, thermal performance, current ratings, blocking voltage, etc.
- Characterise the cooling fluids: Measure their dielectric and thermal properties.
- Design a 20 kV power module combining the elements developed by the project partners into a single ceramic substrate.
- Manufacture, assemble and test the module demonstrator.

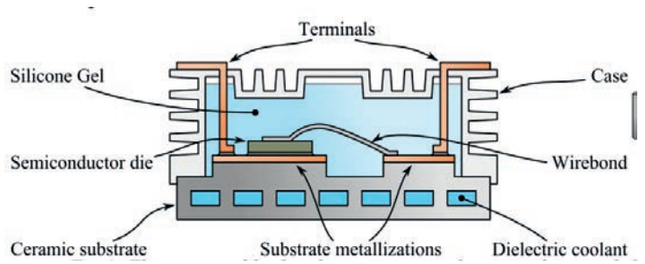
Accomplishments in 2020

Defined the specifications of the module demonstrator including:

- Electrical requirements
- Required thermal properties
- Hydraulic specifications
- Dielectric performance
- Mechanical requirements
- Environmental constraints

Value for energy transition

HVDC technology will play a major role in the energy networks of the future, notably in regards to the integration of renewable energy production. The ARCHIVE project proposes packaging solutions for high voltage semiconductors (20 kV) that make it possible to drastically reduce the size and complexity of HVDC converters and therefore create a more efficient, cost-effective solution for transporting energy.



Power module concept including the ceramic substrate with integrated cooling

Project partners

CeramTec · Hochschule Kempten University of Applied Sciences · Laplace

SICRET – SILICON CARBIDE RELIABILITY EVALUATION FOR TRANSPORT

Assessing the maturity of Silicon Carbide (SiC) power semiconductor technology.

Duration: 3 years / Launched: 2020

Objectives

Allow end users to overcome the technical barriers preventing the wide-scale adoption of SiC technologies and accelerate the time to market by:

- Assessing the most advanced existing commercial and quasi-commercial solutions;
- Tackling the most limiting drawbacks by systematically investigating the underlying physics of failure within a given usage profile;
- Establishing guidelines to define a suitable qualification test strategy for each application's usage profile (rail, automotive, avionic, grid);
- Establishing solutions to mitigate SiC MOSFET's limitations via design guidelines and recommendations (SOA / Robustness / Derating rules for Safety Margins).

Scientific and technical scope

- Define protocols to measure SiC MOSFET's threshold voltage by using the appropriate preconditioning in order to quantify the aging of the device in a given application.
- Assess the SiC MOSFETS device's robustness using short circuit, avalanche and power cycling tests in order to define safe operating margins.
- Test the SiC MOSFETS device's radiation ruggedness by applying neutron beams.

Accomplishments in 2020

- Collaboration agreements signed between SiC Manufacturers and the project members.
- HV test platform specifications validated.
- Contributed actively to exchanges between industrial and scientific experts.

Major milestone

- Report "HV components general test plan and platforms specifications" SiCRET Work Package 4 (lead by SuperGrid Institute) completed. D4.1.

Value for energy transition

The use of SiC on a wide-scale has been hindered by its relative lack of maturity. This project aims to pave the way for the massive adoption of SiC, which has the potential to drastically reduce power losses in converters whilst also increasing their power conversion efficiency. The resulting converters will be smaller and less complex, thereby lowering the overall carbon footprint of energy conversion.

Complete characterisation of a component following HTGS stress tests

Project partners

SMART HUBS FOR FISHBONE INTER-ARRAY CABLE ARCHITECTURES

New subsea technology for an innovative floating offshore wind farm inter-array cable architecture.

Launched: 2020

Objectives

The Smart hub is a subsea technology that makes it possible to implement a new floating offshore wind farm (FOWF) inter-array cable architecture called "active fishbone". This configuration aims to decrease the system's CAPEX and OPEX and increases the wind farm's availability.

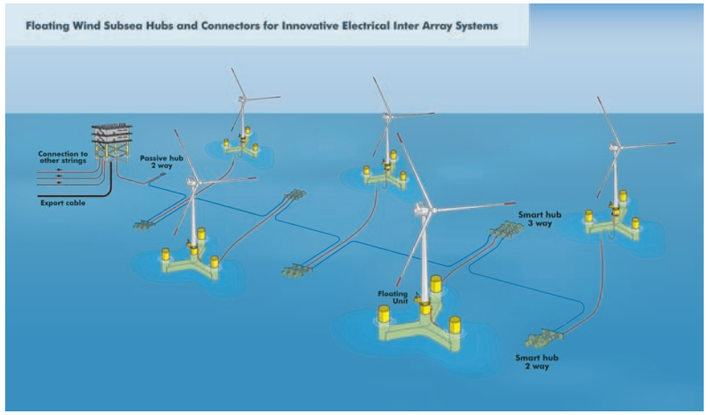
The project aims to develop a three-phase 66 kV Smart hub and validate its performance within an operational environment.

Scientific and technical scope

- Define the required specifications for the Smart hub in relation to today's market.
- Perform advanced electrical simulations of FOWFs.
- Develop and qualify the Smart hub in line with the predefined specifications.
- Perform a gap analysis and prepare for medium to long-term market applications (higher AC voltages, MV and HV DC).

Accomplishments in 2020

- Techno-economic analysis:
  - Cost models developed.
  - Sensitivity study performed (failure rates, depth, power rating).
  - Benefits of the active fishbone architecture compared to conventional daisy chain configurations confirmed in targeted applications (FOWF, water depth up to 200 m, 500 MW + wind farm).
- Functional analysis of the fishbone inter-array cable architecture.
- Collaboration with industrial players to define the path-to-market.



Value for energy transition

Floating offshore wind has a major role to play in the transition towards green energy production. Its wide geographical spread directly contributes to reducing the burden on local electricity transmission grids and decreasing transport losses.

The innovative active fishbone inter-array cable architecture offers a more financially attractive alternative to current FOWF architectures, aiming to reduce annual energy production loss by 25%. It therefore has the potential to increase investor interest in the FOW industry, an industry which encompasses 80% of world's offshore energy potential, and boost its development towards becoming a mature market.

Project partners

Working in collaboration with

HYDROPOWER PLANT HYBRIDISATION

Increasing the flexibility of hydropower stations for improved ancillary services.

Duration: 4 years / Launched: 2019

Objectives

- Develop a supervisor for the joint control of hydroelectric turbines & rapid energy storage systems (ESS).
- Complete a techno-economic analysis of the most suitable ESS technology and define its optimum size.
- Investigate how to physically connect the ESS to the existing hydroelectric plant.

Scientific and technical scope

- Model & simulate the hydroelectric turbines & rapid energy storage systems (ESS).
- Develop a supervisor based on the simulation models.
- Validate the supervisor using a Hydro Power-hardware-in-the-loop platform (Hydro PHIL).
- Complete a Pareto front analysis of performance vs. cost.
- Select the most appropriate power electronics solution to connect the ESS and the existing hydroelectric plant.

Accomplishments in 2020

- Defined the supervisor performance criteria.
- Developed a methodology to assess the supervisor's performance.
- Performed the first simulations.
- Constructed the mock-up for the HydroPHIL platform that will be used to validate the hybridisation technology.

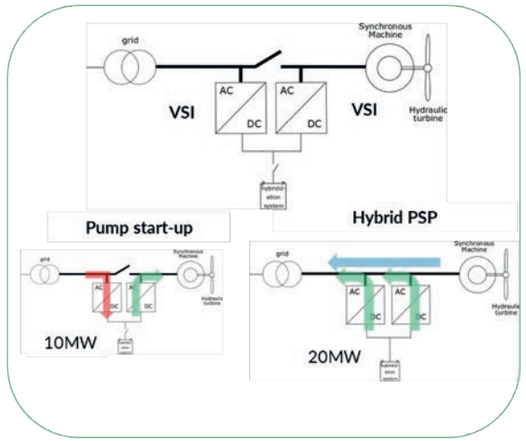
Major milestones

- Patent pending: FR2006852 - Power transfer system between an AC network and a reversible hydraulic turbine.
- Patent pending: FR2006855 - Power generation system including a hydraulic turbine, with an improved dynamic response.

Value for energy transition

Hydraulic turbines, and more specifically Pump Storage Plants (PSP), are becoming increasingly important within the grid because of their potential for balancing excesses of demand and production with the integration of variable renewable energy sources (RES).

The hybridisation of hydro power plants with energy storage systems means faster response times and a lower carbon footprint than other existing solutions.



Patented solution for the integration of an Energy Storage System (ESS), taking advantage of the existing Speed Frequency Converter (SFC) of a given Pump Storage Plant (PSP)

Project partners

FINANCIAL ANALYSIS OF NEW HYDROPOWER TECHNOLOGIES

XFLEX HYDRO

Studying the long term profitability of new flexible hydro technologies.

Duration: 4 years / Launched: 2019

Objectives

The XFLEX HYDRO project aims to develop technologies to make hydropower more flexible. SuperGrid Institute is leading the work package responsible for:

- Developing cost models for the technologies XFLEX HYDRO technologies.
- Optimising hydropower plants' revenues within multiple markets.
- Assessing the potential for deployment of new hydropower technologies across Europe.

Scientific and technical scope

- Apply activity-based costing methodology to develop CAPEX models.
- Simulate future prices across the day-ahead & reserve markets.
- Optimise unit placement within the analysed markets.
- Complete a sensitivity analysis of the technology's profitability within various scenarios.
- Cross-reference profitability analysis with European hydropower database.

Accomplishments in 2020

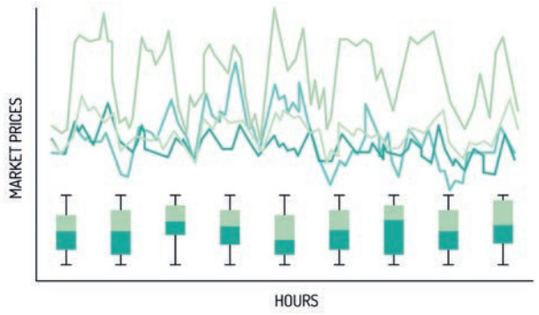
- Developed the first draft of the CAPEX model for each of the 4 XFLEX HYDRO technologies.
- Carried out a review of the operational structure of current and future reserve markets across Europe.
- Designed methodologies for market price simulation and unit placement optimisation.

Major milestones

- Report on "Common Methodology to Assess Cost of Hydroelectric Flexible Technologies" XFLEX HYDRO Work Package 11, deliverable D11.1.
- Quentin Boucher "XFLEX HYDRO project: demonstrating enhanced flexibility of new hydropower technologies" at the 8th Annual Grid Integration & Electricity Ancillary Services 2020 conference.

Value for energy transition

Analysing future market needs & the potential profitability of new flexible hydro technologies is essential for developing a robust new energy ecosystem capable of maximising the use of renewable energy sources. Providing reliable financial forecast information allows the energy industry to focus their resources on technologies that will remain useful and profitable in the long term.



Market price simulation: Theoretical hourly prices for day-ahead & reserve markets

Project partners

SuperGrid Institute's success comes from the wealth of experience gathered together in its various research programmes. The company's teams come from various backgrounds in industry and academia, with each individual bringing their own specific expertise to the table. This melting pot of knowledge makes SuperGrid Institute truly special and provides unique opportunities for specialists from different fields to collaborate and find new innovative solutions to technical problems. Such was the case for this project, which was run jointly by the High Voltage Substation Equipment and HVDC Cable Systems & Junctions programmes.

Epoxy composite laboratory at SuperGrid Institute

INNOVATIVE EPOXY COMPOSITE FOR HVAC AND HVDC

Improving the reliability & capacity of gas insulated substations.

Duration: 6 years / Launched: 2016

Objectives

Formulate a new epoxy composite that can withstand both HVAC & HVDC:

- Improve the insulating properties of spacers for HVAC equipment.
- Be ready to face the new insulation challenges that HVDC presents.

Scientific and technical scope

- Optimise fillers to withstand higher electrical stresses and retain their insulation properties for longer.
- Adapt the insulation's DC electrical conductivity to manage space charges & avoid problematic charge accumulation caused by HVDC stress by developing a new matrix.

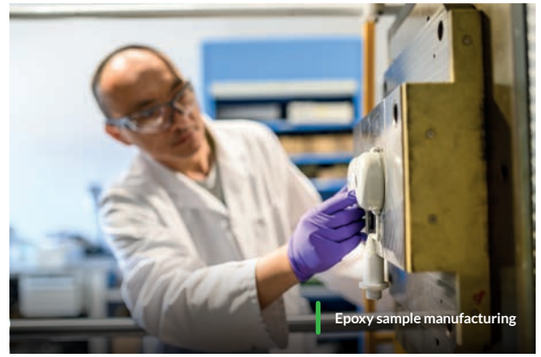
By combining optimised fillers with the new matrix, the innovative epoxy composite formulation will be ready to face the challenges of both HVAC & HVDC.

Accomplishments in 2020

- Selection and optimisation of a unique epoxy composite formulation.
- Characterisation of the new formulation's properties.
- Significant advances in defining and understanding the injection process.

Major milestones

- PhD Loriane DESMARS "Study of electrical and thermal properties of epoxy-anhydride composite materials for high voltage insulation".



Epoxy sample manufacturing

- Phd Thibaut LEFORT "Epoxy/ionic liquid networks with and without anhydride: study of polymerization mechanisms and dielectric properties".
- Patent pending: WO2020016525 - Electrical insulation material comprising a mixture of micrometric inorganic fillers and its manufacturing process.
- Patent pending: WO2020/141280 – Electrical insulation material and manufacturing process.
- See the relevant publications on page 72.

Value for energy transition

By developing a new epoxy composite that can withstand higher voltage, and for longer, thanks to improved dielectric properties, it is possible to reduce the size of HVAC substation equipment. Additionally, by ensuring this composite is already HVDC compliant, we can construct both HVAC & HVDC GIS using reliable & durable spacers, thereby improving the compactness and availability of the future supergrid.

Project partners

08 | FINANCIAL SUMMARY

SUPERGRID INSTITUTE'S FINANCIAL STRUCTURE

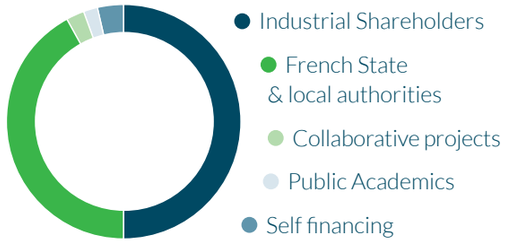
SuperGrid Institute is owned by public and private minority shareholders. This ensures the company's independence and imposes a mutual decision-making process.

Since 2014, the company has been financed by:

- funding from the French State's Investments for the Future programme (PIA)
- subsidies from local authorities (Auvergne-Rhône-Alpes Region and Greater Lyon)
- investments by industrial shareholders, either as capital or subsidies
- contributions from academic shareholders, including staff secondments to SuperGrid Institute
- European funding via new collaborative projects
- self-financing, through the company's commercial activities.

This financial structure is guaranteed for the first ten years of SuperGrid Institute's activity, following which the company will be self-sufficient, covering the cost of its research and development (R&D) activities with the revenues generated from its technologies (intellectual property), platforms and services (consultancies, training). Additionally, certain research projects will be eligible for subsidies from the French State and/or European Union.

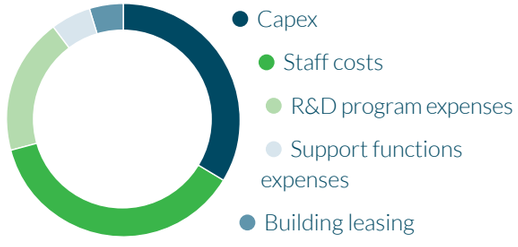
SuperGrid Institute Funding for first 10 years



EXPENDITURE

Two-thirds of the Institute's overall funding is allocated to R&D expenses, with staff representing roughly 50% of these costs. The remaining third is dedicated to a capital expenditure investment plan, which allows SuperGrid Institute to differentiate itself from competitors thanks to its innovative, highly advanced testing and research facilities.

SuperGrid Institute's expenditure for first 10 years



FINANCING THE FUTURE

SuperGrid Institute's ambitious R&D investment plan will stimulate innovation over a long-term period. The company's capital and equity are reinforced every year through capital increase, which is made possible by the confidence its public and private shareholders place in the Institute. While SuperGrid Institute is expected to make a loss during its first decade, the initial funds invested will ensure that the Institute has the necessary resources to become self-sufficient after this start-up period.

2020 FINANCIAL OVERVIEW

In 2020, SuperGrid Institute saw a considerable increase in its consulting and services activities, with a turnover that more than doubled compared to 2019; platform revenues were slightly higher (+18%) than in 2019.

Fruitful negotiations with major partners – on intellectual property for decisive and differentiating technologies – were underway in 2020. While they are not reflected in the revenues from 2020, they should ensure contractual commitments over the long term.

SuperGrid Institute's costs were 18% below the 2020 budget. This was largely due to lower R&D and depreciation expenses caused by certain projects being postponed to 2021.

In 2020, the combination of steady revenues and lower costs gave a positive outcome when compared to the budget, reinforcing confidence in the company's capacity to run its R&D programmes effectively while securing a robust financial structure for its future.

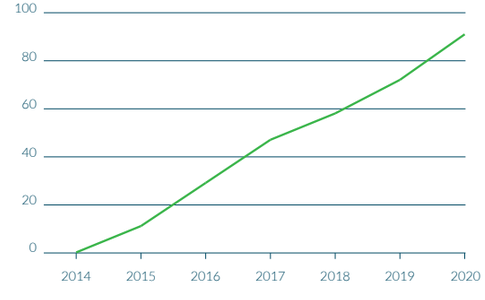
Regarding the investment plan, 2020 was a strong year with more than EUR 17 million invested, including almost EUR 15 million for the main platform (short-circuit generator) under construction.

Mid-year 2020, despite the impact of COVID-19, the company's industrial shareholders renewed their expression of confidence in SuperGrid Institute, making a firm commitment to the 2021-2024 funding plan. This was followed by another key step when the French State renewed its contract with SuperGrid Institute, confirming its status as a French Institute of Technology (ITE) and guaranteeing their financial contributions over the next four years. The State has, thereby, committed to investing EUR 17 million in capital via its affiliate the Caisse des Dépôts et Consignations, with a further subsidy of EUR 6 million to be paid out over 2021-2024 by the French National Research Agency (ANR).

These commitments by the Institute's industrial shareholders and the State, combined with the continued implication of its academic shareholders, formalise the ongoing support for SuperGrid Institute and demonstrate the trust placed in the company as a driving force of innovation in France's industry and energy transition. They demonstrate the importance shareholders accord to the Institute's research and development work: developing the electricity grid of the future and integrating renewable energies on a massive scale. This renewed support ensures that SuperGrid Institute's critical work will continue and grow over the coming years.

Tangible, intangible and financial assets (million EUR)

Capital (million EUR)



Open space offices at SuperGrid Institute - Villeurbanne

09 | CORPORATE SOCIAL RESPONSIBILITY

At SuperGrid Institute we are committed to our corporate social responsibility: to ensure well-being and create a working environment that is responsible, ethical, sustainable and respectful. This begins with our team members but also extends beyond the Institute through our outreach activities and into our greater ecosystem.

A SPIRIT OF SUCCESS…

SuperGrid Institute is a research and innovation centre with an enterprising spirit and impressive growth. We pool the expertise of specialists from diverse domains of research in a stimulating work environment equipped with state-of-the art test platforms and resources. As they interact and share their knowledge and vision of the energy sector and its issues, they enable us to develop innovative competencies, technologies and solutions that address market needs.

… BUILT ON DIVERSITY

At SuperGrid Institute we are proud of the diversity of our workforce. Our teams include experts seconded from private and public partners, as well as many brought on board through external recruitment. Our staff come from all over the world, representing a total of 29 different nationalities. This richness and diversity are reflected in our corporate structure and in the scientific and strategic committees that guide our activities.

COMPANY VALUES

In 2020, SuperGrid Institute worked to define its core values:

- Responsibility: acting to make energy transition a reality.
- Fertility: being open minded in a collaborative environment and cultivating ideas to benefit our ecosystem.
- Expertise: capitalising on knowledge and developing talents to meet the challenges facing our clients.
- Vigour: unleashing energy to be a driving force for change.
- Pleasure: working together cheerfully and enthusiastically.

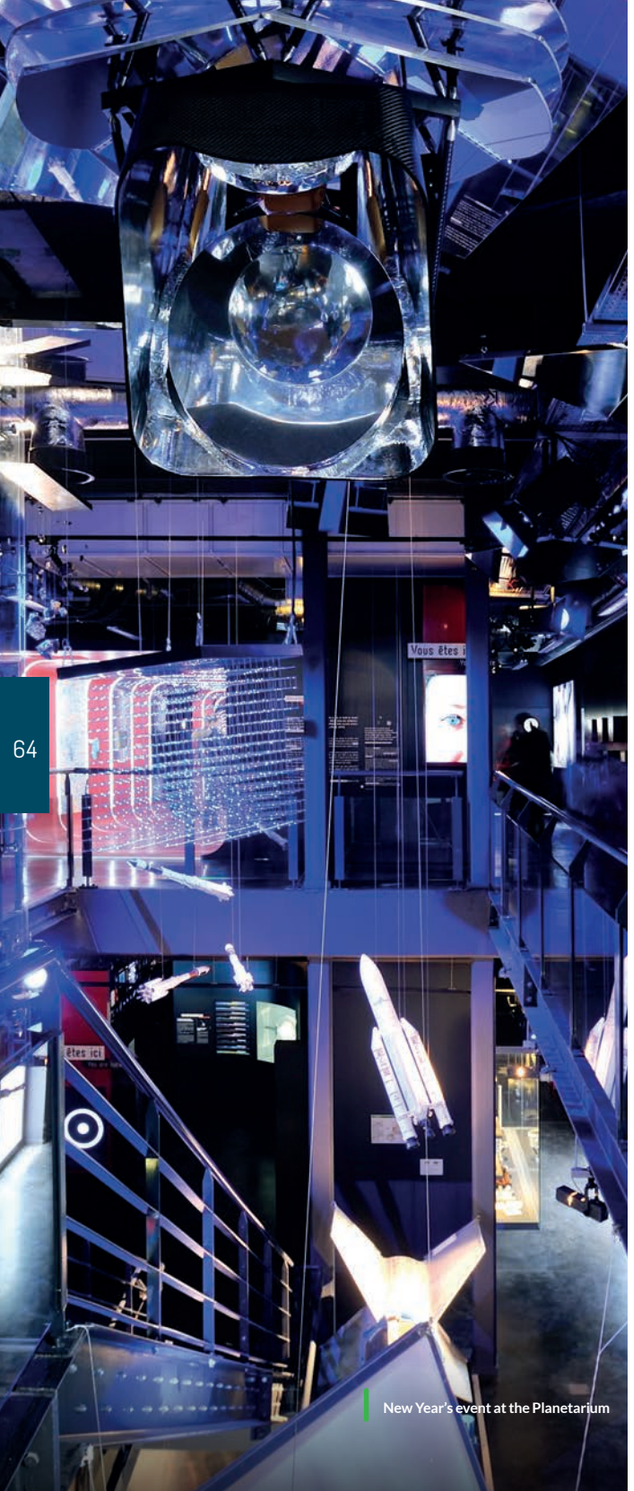
We are in an active phase of introducing these values to our staff and encouraging their uptake.

> “The secret of SuperGrid Institute’s success is its teams, made up of highly qualified specialists from all over the world. Each staff member plays an integral role in our development. They are the heart of the company.”
>
> *Eléonore Magni, Human Resources Manager*

EQUALITY IN THE WORKPLACE

SuperGrid Institute is committed to ensuring equality in the workplace. We are constantly seeking highly qualified, proactive individuals who are keen to contribute to the company’s growth and help us build the Institute’s future. We assess all job applications based on the candidate’s qualifications, skills, professional experience and education. We take affirmative action to ensure that discrimination has no place in our recruitment processes and in our company. All positions at SuperGrid Institute are accessible to people living with a disability.

We believe in equal pay for equal work according to each employee’s responsibilities, education, experience and professional skills. We offer each staff member opportunities for professional development in a promising field – the future electricity transmission network.



New Year's event at the Planetarium

STAFF COHESION AND SAFETY IN THE CONTEXT OF COVID-19

SuperGrid Institute's priorities in terms of staff cohesion are clear: creating a unified working environment for all; regularly sharing the Institute's achievements, development and vision; and promoting interaction and exchanges. In the face of the pandemic situation in 2020, we reacted quickly to protect staff and ensure that they could continue to be productive under these challenging circumstances. This meant working from home for many, but we also put in place strict safety measures to protect those who – because of the nature of their work – are obliged to work on premises.

We have made special efforts to continue to celebrate our regular staff events, which provide valuable opportunities for social interaction, exchanges around the company's strategy, and simply to learn what other colleagues are doing. At the start of the year, before the context of COVID-19, we held our annual New Year's celebration at the Planetarium in Vaulx-en-Velin (Lyon), a relaxed, friendly event among colleagues which was greatly appreciated. Our Mid-year event took the form of a webinar and provided a valuable opportunity for each department to share their progress throughout the first half of the year and their vision for the upcoming months. Finally, 'Values meet-ups' were held within the strict measures required by the COVID-19 pandemic to help staff assimilate the new company values.

STAFF REPRESENTATION

In 2020, SuperGrid Institute organised the election of its first Social and Economic Committee by employees. This body, with 10 elected members, represents staff in exchanges with management. It organises social and cultural activities for employees, with a budget allocated by the company, and also deals with issues relating to staff health and safety at work.

In 2020, SuperGrid Institute…

Bike-repair workshop during the Mobility Challenge

PROMOTED GREEN TRANSPORT

For the second time, we took part in the Mobility Challenge, asking our teams to use green modes of transport to get to work. We also invited two companies to our headquarters to give cyclists advice and offer bike-repair workshops. A total of 89 employees took part in these events at our Villeurbanne and Grenoble sites, covering a total distance of 1,045 kilometres on their journeys to and from work.

MADE CONTRIBUTIONS TO THE COMMUNITY

- On the occasion of Breast Cancer Awareness Day, we conducted an awareness campaign among our teams and organised a fundraiser to support cancer research at the Centre Léon Bérard in Lyon.
- At the outbreak of the COVID-19 pandemic, we delivered protective equipment from our stock to local hospitals (masks, protective clothing and gloves).
- We organised a blood drive on our premises, enabling 72 employees to donate blood.

Research engineer working on the high current switching test bench

10 | PERSPECTIVES: GENERATING ADDED VALUE

An interview with Michel Augonnet, President and Hubert de la Grandière, Chief Executive Officer of SuperGrid Institute.

WHAT IS YOUR VISION FOR 2021?

MA SuperGrid Institute is becoming well known and our partnerships and prestige are growing. We have been able to demonstrate our capabilities in research as well as our reliability as a partner. In 2021, we will continue to build the strength of our existing partnerships and to bring on board new partners, expanding the number of potential projects. We have secured the financial means required and we have matured in terms of commercial deployment.

HdlG I see 2021 as 'the year of interaction with the market' as we work to build our project and customer management skills. We are a research organisation, but more and more we have to become a business organisation as well, and this implies a real transformation for the Institute. We are putting in place a methodology and framework to support the transformation, and we are bringing on board customer relations specialists. The challenge will be to maintain a productive balance between research and development, on the one hand, and customer service on the other.

WHAT MAJOR UNDERTAKINGS DO YOU FORESEE OVER THE COMING YEAR?

MA In 2021, we plan to complete the commissioning of our high power source facility. This will enable us to deliver services and perform high voltage DC breaking tests for our research and for our clients. We plan to expand our partnerships, working on large European projects that involve multi-terminal direct current (MTDC) grids, as well as high and medium voltage direct current (HVDC and MVDC) technologies, areas where our expertise is recognised. Finally, we will continue the push to create value from our intellectual property, patents and research results.

HdlG Our HydroPHIL platform is a major undertaking – the first of its kind in Europe. The research results it provides will make it possible to increase the role of hydroelectric power plants in providing grid flexibility. This real-time dynamic platform will be useful, in particular, for work on various European projects, such as XFLEX HYDRO and LOLABAT. It will also enable us to provide consulting services for our clients and will be important for our own research and development.

We have numerous new projects in the pipeline. This includes proposals for two major European collaborative projects. On one of them our partners, who include several European transmission system operators, have asked us to take the lead should we win the bid, demonstrating the trust they place in us. The LOLABAT project is at the heart of the value proposition of our power storage and balancing research programme, and the SiCRET and ARCHIVE projects leverage our platforms and patents in the field of power electronics. Whatever the results of the bids we still hope to win, the collaboration that has gone into preparing these projects will serve as the cornerstone for new projects and prospects.

High power source & test hall buildings, Villeurbanne

HydroPHIL test platform, Grenoble

> "We have numerous new projects in the pipeline. This includes proposals for two major European collaborative projects."
>
> *Hubert de la Grandière, CEO*

WHAT ARE THE CHALLENGES AHEAD?

MA I travel quite a lot in many roles, and in my travels I am getting a lot of very positive feedback on SuperGrid Institute. There is a lot of traction and awareness. People are interested in the work we are doing, which is at the centre of many things that people are passionate about – renewable energy and technological innovation, among others. They want to be involved. The market is booming in terms of opportunities – and this is just the beginning. Now is the time to grow our ability to execute, delivering quality and doing so on time. We are still a new organisation, so we have many things to learn, but our progress is rapid and our path is clear.

Medium frequency transformer test platform

Dielectric test rig

HdlG Our goal is to provide solutions that encourage the integration of renewable energy into the networks. We want SuperGrid Institute to be recognised as the HVDC champion. We also have an important role to play in building the network of the future for MTDC transmission systems. Positioning ourselves in this area will be a major challenge. As Michel has mentioned, we need to generate sufficient added value that is 'usable by industrialists' – whether in the form of services or of intellectual property – for the institute's economic model to be sustainable.

> "People are interested in the work we are doing, which is at the centre of many things that people are passionate about – renewable energy and technological innovation, among others. They want to be involved."
>
> *Michel Augonnet, President*

Investigation and qualification tests on AC and DC power cable systems

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SuperGrid Institute
Shaping power transmission

23 rue Cyprian CS 50289
69628 Villeurbanne Cedex France
+33 (0)4 28 01 23 23

contact@supergrid-institute.com
www.supergrid-institute.com