WHAT ARE THE R&D PRIORITIES FOR BUILDING THE ENERGY GRIDS OF TOMORROW?

Scientific Council R&D Roadmap

think SMARTGRIDS

FRENCH SOLUTIONS FOR SMARTGRIDS

R&D PRIORITIES TO MEET THE CHALLENGES OF THE ENERGY TRANSITION

In December 2015, 195 countries adopted the Paris Agreement[1] and committed themselves to drastically reducing their greenhouse gas emissions in order to limit the increase in global temperature to +2°C by the end of the century.

At the European Union level, this commitment is reflected in the adoption of three key objectives: a 40%[2] reduction in greenhouse gas emissions, a 32% share of renewable energies, and a 32.3% improvement in energy efficiency by 2030. At the national level, the French government has drawn up an energy roadmap that aims to achieve "carbon neutrality" by 2050[3]: +55 GW of renewable capacity installed within 10 years, 6 GW of demand reduction in the building sector within 5 years, 7 million charging points for electric vehicles by 2030...

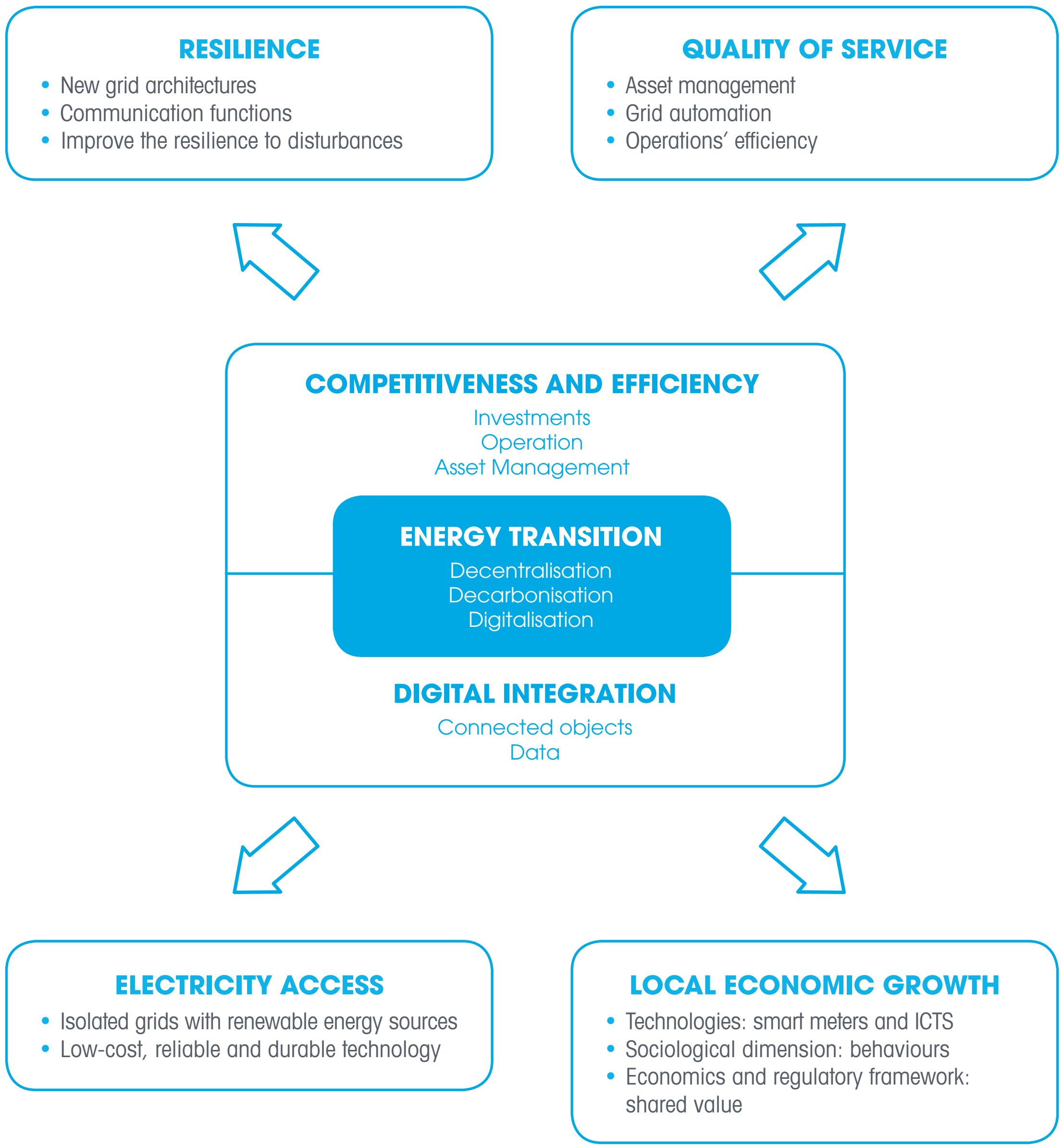
This energy transition is accompanied by a new digital revolution that redefines the way systems work ('Big Data', connected objects, AI, Blockchain, virtual/enhanced reality...) and changes consumer behaviour with the emergence of the active customer.

These challenges lead to a need for a profound transformation of the electricity grids towards more "intelligence" and efficiency (complexity of systems, need for a system vision, rationality of the necessary investments...).

To achieve this objective, a collaborative approach focused on innovation between the various actors in the electricity grid sector and a structured investment programme are needed (33.5 billion euros[4] were invested in 2018 by the European Union in electricity grids, and this amount should significantly increase over the next decade).

Think Smartgrids' Scientific Council has identified 7 R&D priority areas to be promoted in the short term in order to meet these major challenges and position French players in a sustainable way on national, European and global markets.

1. The Paris Agreement, signed by 195 countries at the Paris Climate Conference (COP21), provides for global warming to be contained by 2100 "well below 2°C compared to pre-industrial levels" and, if possible, to aim to "continue efforts to limit temperature increases to 1.5°C".
2. Compared to 1990 levels
3. In December 2018, the French government published its National Low Carbon Strategy, which sets out the path for the energy transition to "carbon neutrality" by 2050. In January 2019, the multiannual energy programme set the priority actions at 10 years, including the gradual substitution of fossil fuels by carbon-free energy sources, the mobilisation of new technologies in the transport sector, and the control of energy consumption in buildings.
4. IEA



AERA 1

R&D AT THE SERVICE OF THE ENERGY TRANSITION

The energy transition aims to decarbonize the energy mix while improving the efficiency of systems and network infrastructure. For the electricity grid, this ambition is reflected in the increasing integration of renewable energies. This decentralized and often variable energy production requires the implementation of new planning and operating strategies at all scales: storage, electric mobility, multi-energy management, etc.

Tools for forecasting electricity production and consumption must therefore be developed and disseminated: real-time management of energy production and storage sites according to demand, weather conditions, network constraints, changes in price signals, coupling of energy networks, etc. A better understanding of networks and systems will also lead to better investment planning and cost-efficiency optimization.

In parallel, the optimization of these complex systems (diffuse storage, fleets of versatile electric vehicles, etc.) requires finer and more intelligent network management: control of highly variable flows, frequency/voltage adjustments with distributed resources, detection and resolution of congestion, multi-energy networks, and exploitation of cross-flexibility between energy carriers. Active energy demand management also appears to be an interesting flexibility tool for the management and economic optimization of the global system.

Beyond the development of technologies, this energy transition will have to be accompanied by an adaptation of regulations and the creation of new business models that take into account the cost/benefit equation for each of the players and for the community.

ISSYGRID, SMART GRID USE-CASES SCALED UP TO AN ENTIRE URBAN DISTRICT (ENEDIS - PARIS)

IssyGrid is a demo-project led by Enedis and about 10 industrial partners for a large range of smart grid use-cases that have been scaled up to a whole urban district: flexibility, storage, integration of local solar power, smart electric vehicle charging, smart lighting, as well as applications for power consumption optimization in households and office buildings.

AERA 2

MORE COMPETITIVENESS AND EFFICIENCY

The competitiveness and efficiency of the electricity system (sizing, asset utilization, cost, etc.) are based on integrated management of the entire life cycle, from investment to network maintenance and operation.

In terms of investment, the design of an efficient electrical system requires an ever-increasing complexity to be taken into account. To this end, several dimensions must be considered: environmental constraints and values, in addition to technical and economic dimensions, when seeking an optimum for the entire system. This complexity is reinforced by the development of "smart" digital solutions that compete with traditional network dimensioning and planning levers.

In terms of network asset management, new technologies are emerging for real-time monitoring and predictive evaluation of component aging. These technologies take advantage of ever-increasing amounts of data, with the development of advanced monitoring softwares, IoT and Big Data. They will make it possible to better anticipate technical problems and optimize expenses related to the maintenance of heterogeneous equipment with different life cycles.

This also includes the development of new diagnostic methods based on, among other things, artificial intelligence, image or signal processing, the deployment of connected objects, including objects connected with the Linky metering infrastructure, and innovative solutions to improve sensors, protections, power electronics devices, etc.

In addition, in order to enable the electrical system to operate as close as possible to its physical limits, with the aim of increasing its efficiency and reduce its costs, it is necessary to better monitor the actual operating conditions. This allows for a more dynamic network management, based on the use of PLCs, real-time reconfiguration systems, and other forms of flexibility.

NICE SMART VALLEY, NEW FORMS OF FLEXIBILITY FOR LOCAL POWER SYSTEMS (SOUTH REGION)

NICE SMART VALLEY

Nice Smart Valley is part of the European project Interflex, in the framework of the Horizon 2020 program, involving 20 partners across Europe to experiment with new forms of flexibility.
In France, the project tests smart grids solutions in order to integrate renewable energy sources and electric vehicle charging stations into the grid. Experiments include collective self-consumption with storage systems in a residential district, the complementarity of the gas and electric grid, and temporary islanding on the scale of a neighborhood. Finally, the project provides the Nice Côte d'Azur metropolis with a wide variety of data concerning the electricity distribution grid and the flexibilities enabling to control its energy consumption and make savings.

AERA 3

OPTIMIZED POWER QUALITY

Improving power quality, i.e. continuity of supply and wave quality, requires innovations in network automation and operations.

Network automation and the integration of advanced control functions must lead to a better quality of supply and more flexibility: self-healing, advanced observability including in low voltage, predictive tools...

Power quality also involves exploiting the potential offered by grid-connected electronic converters: converters for wind turbines and photovoltaic systems, electric vehicle chargers, and all the equipment dedicated to a better management of the physical quantities of the grid (voltage, frequency, flow).

Improving operational efficiency also involves strengthening the safety of stakeholders, speeding up interventions and capitalizing on information. To achieve these objectives, augmented / virtual reality and artificial intelligence are new tools with great potential.

AERA 4

A RESILIENT SYSTEM

Electricity infrastructures are facing new constraints that risk undermining their resilience to hazards: climate change, intermittent renewable production, or interconnection of the Internet of Things (‘IoT’) infrastructure. Their operating conditions and stability are changing with the decrease in inertia, the development of power electronics technologies and perhaps the emergence of direct current networks.

It is therefore essential to work on structural and operational solutions that can help the system to maintain and even improve its resilience in a context of high uncertainty, while limiting additional costs.

The adaptation of components and the design of new architectures will make it possible to strengthen the operational integrity of the networks: intelligent protection, adaptation of equipment to climate constraints, or even native integration of appropriate storage.

At the operational level, the deployment of new communication standards for Smart Grids (redundancy, G3 PLC, 5G, multi-channel, IEC61850...) as well as the improvement of telecontrol hardware components (MIL STD) appear to be priority projects, in order to improve the management of local resources, whether in terms of energy production, consumption or storage.

AERA 5

MAKE ELECTRICITY MORE WIDELY AVAILABLE IN DEVELOPING COUNTRIES

Local microgrid-type networks provide an answer to the electrification problems of some remote rural areas, as well as to the management of "energy islands", isolated or not from the main grid, or to the specific needs of industrial sites.

However, their development requires innovation to design systems adapted to different configurations of energy needs and available resources. This requires system scalability, larger interconnection capacity when necessary, low inertia operation, low redundancy, etc.

In addition, the design of these systems will have to more effectively integrate the high variability of renewable sources in the future, at increasingly large scales. The stability of these systems is then based on the development of specific methods for optimising the dimensioning of energy reserves, and tools for anticipating production and demand.

The sustainability of these installations requires the design of suitable components as well as the establishment of local production structures, offering a guarantee of income for the maintenance of the system, and the training of local operators, with a model adapted to the specific conditions of the countries.

USHANT, 100% RENEWABLE ENERGY NETWORK FOR ISLAND TERRITORIES (SMILE BRITTANY)

On island territories such as Ushant, which are not connected to the continental electricity grid, electricity is produced by oil-fired power plants that emit high levels of CO_2 and are costly to maintain. Ushant aims to achieve 100% of renewable energy production by 2030.
A 3-year action program started in 2017 to reduce energy consumption (building insulation, LED public lightning, awareness program, etc.), locally produce renewable energy, and develop electric mobility with charging stations powered by solar energy. In parallel, the "ICE" Project (Intelligent Community Energy), a French-English cooperation, aims to develop the production, storage and consumption of low-carbon energy in isolated territories, through the use of smart grids technologies.

AERA 6

SEIZE THE OPPORTUNITIES OF DIGITAL TECHNOLOGY

The digital revolution ('IoT','Big Data', IA, 5G, virtual/enhanced reality...) offers new opportunities for electrical networks (predictive maintenance, automation...). However, R&D investments are needed to adapt emerging digital technologies to the network environment.

The two main challenges are system cybersecurity, with many interfaces and a wide geographical distribution, and the design of an efficient Smart Grid IS architecture.

This includes the development of telecommunications tools adapted to the environment of electricity networks: sensors, augmented reality models, electrical infrastructure monitoring systems, etc. But also by designing an IS architecture that combines distributed and centralized intelligence, and that allows the interoperability of heterogeneous systems.

AERA 7

A LOCAL AND COLLABORATIVE SYSTEM THAT MEETS THE NEW EXPECTATIONS OF CUSTOMERS

"Smart meters" offer end customers a better understanding of their energy consumption and of the origin of the energy consumed, paving the way for more "intelligent" energy management. At the same time, consumers are encouraged to deploy their own means of production (photovoltaic, biomass, etc.) or storage, and to develop new uses, such as electric vehicles and intelligent charging stations.

Thus, the "prosumer" can make new trade-offs on his equipment, which he controls individually or collectively, within "energy communities", and act directly on the energy system, in particular through demand response and self-consumption.

These new uses are reinforced by the development of a new class of tools facilitating decentralized energy exchanges and their traceability to a local grid: "Blockchain", "Smart Contracts", "green" crypto-currency, etc.

This enriched "informational" environment creates a new paradigm for the orientation of local energy policies (circular economy, local means of producing green energy, etc.) and the emergence of a new perimeter of local democracy, linked to the emergence of various forms of self-consumption and the Smart City or eco-districts.

A COLLABORATIVE APPROACH TO WIN NEW MARKETS

The implementation of these R&D programmes requires relying on the know-how of the major French players in the field of Intelligent Electrical Grids (academic world and research centres, utilities, component manufacturers and solution providers, network operators, etc.), but also on the existing ecosystem of SMEs, start-ups and local competitiveness clusters, which must be supported and developed.

The implementation of a structured investment plan through a collaborative approach between these different players will make it possible to develop the Power Systems sector in France, export its know-how internationally, and create local value (job creation...).

This ambition is in line with the approach of the Think Smartgrids professional association, specialising in Intelligent Electrical Networks and bringing together more than 100 players throughout the smart grids value chain in France (electrical and electronic engineering, automation, information systems, services, regulation, etc.) - whose mission is to help the sector develop in France and promote the know-how of its members internationally.

THE SCIENTIFIC COUNCIL

The Scientific Council of Think Smartgrids defines the priorities for R&D in the French smart grids sector, sheds light on its technological choices, references all theses on smart grids and awards the association's thesis prize.

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Conception and realization: Agence 9 I Une bulle en plus - 2019