The electricity fairy's digital wand

Patrick Morilhat,
head of a research program on improving the performance of nuclear power stations, Department of R&D, Électricité de France (ÉdF);
& **Thomas Bladier,**
head of a research program on customer relations, smart homes and digital technology for sales and energy services, Department of R&D, Électricité de France (ÉdF)

For: In R. Lavergne & H. Serveille, editors of The digital and environmental transitions, a special issue of Responsabilité et envrionnement.

Abstract:
Électricité de France (ÉdF) is accelerating its digital transformation in order to provide a sure, competitive and lasting supply of low-carbon energy, to offer the services expected by customers and to reinforce its position among world leaders in the energy sector. Digitizing internal processes and customer relations, developing smart grids, and using virtual reality and artificial intelligence to simplify the design and operation of production processes… these innovations not only bring productivity gains but also lastingly transform jobs in the company and, thus, modify the needs for skills and qualifications. What advances to expect from the digital transformation under way at ÉdF? What questions will arise? How to involve the persons affected by this transformation at all levels? What are the keys to success, and the factors of risk?

Digital technology, a fundamental lever for making the nuclear industry more competitive

The fourth industrial revolution, based on the massive use of digital technology, is under way in all branches of the economy.[1] Beyond the tremendous technological progress that we notice from one day to the next, the digital transition is an essential lever for making firms more competitive. It is also an incredible vector of disruption in organizations, occupations and all along the chain of value creation.

It comes naturally, therefore, that the French nuclear industry and, in the first place, its leader ÉdF (Électricité de France, the French national electricity utility) is committed to this digital transition. The objective is, of course, to become more competitive in operating and renovating the fleet of existing power stations or in international projects, but also to improve cooperation among partners in the French nuclear industry — the country's third major industry (following aeronautics and automobiles) with 2500 firms.

For ÉdF, the digital transition is not something completely new. The company has been extensively using digital technology since the 1980s for simulations and model-building in physics and for controlling and monitoring procedures. Let us point out that ÉdF, along with several other firms in France, digitally designed and then built two nuclear power stations (Chooz and Civaux) with fully computerized control rooms at the turn of the century — a first worldwide at the time.

[1] This article has been translated from French by Noal Mellott (Omaha Beach, France).

By comparison, the digital revolution under way has THREE NEW DIMENSIONS: the recent acceleration of technological progress; its implications for an installation's life cycle; and the importance of "digital continuity" to make sure that both the principal and agents to a contract advance at the same pace in the quest for gains.

The FIRST DIMENSION is technical: the automation of processes and the switch from anagogical to digital systems; the development of the Internet of objects (IoT); the resulting increase in data flows; and the strides made in artificial intelligence, whether due to the power of algorithms or increased computational intensity. An example of a current innovation on this dimension is the predictive maintenance of components and materials. These so-called e-monitoring systems, developed at the start of the century, have been successfully deployed at ÉdF's power plants (nuclear, thermal and hydraulic). What is now needed is to expand the scope of monitoring to all processes and to fit unequipped ("orphan") installations out with low-cost (if possible, wireless) instruments (exchangers, valves, etc. mainly in the secondary facilities at power stations). The progress being made in big data technology and methods of machine-learning open possibilities for working out solutions that are more agile, less expensive and less dependent on the technology installed. Such solutions will make it easier to cross data from diverse sources (for instance, digital data from current processes and textual data from maintenance reports).

The SECOND DIMENSION of the ongoing digital revolution is related to a time factor, namely: an installation's life cycle. There are software applications for designing reactors (through simulations), operating and maintaining installations (through virtual imagery, enhanced reality and artificial intelligence) and dismantling installations (with the help of robots). An example of an underway innovation on this dimension is virtual reality and immersive techniques. R&D at ÉdF has developed a tool for virtually visiting a nuclear reactor thanks to high-definition panoramic photographs (360°), 3D laser scans, CAD data and blueprints. For a year now, this tool has been used to prepare the *grand carénage*, ÉdF's plans for overhauling existing nuclear power stations to keep them longer in use. Thanks to a technology borrowed from video games, a technician virtually moves around inside a reactor building to prepare interventions (for example, to determine the optimal height of scaffolding or to check, down to a decimeter, how much room is necessary for the intervention). Deep-learning technology is also being used to automatically detect, on masses of photographs, the objects or evidence that identify certain materials.

The THIRD DIMENSION is organizational: the relations between ÉdF and its partners. While a power station is operating, ÉdF is the source of most of the added value. In contrast, when installations are periodically halted, this value is mainly created by maintenance companies. Productivity gains thanks to digital technology have to be made all along the chain from the contracting authority to all contractors and second-rank subcontractors. This "digital continuity" in a big firm's operations entails reaching agreements on the ownership and sharing of data, on the tools to be used and their interoperability, on the adoption of joint standards for naming objects or concepts, etc. To make headway along this dimension, ÉdF has set up a Digital Transition Club for devoting thought to setting up a joint digital platform with its partners (like the BoostAerospace platform in aeronautics). The objective is to enable stakeholders in the nuclear industry to work together on the same project while sharing documents, models, etc., and seeing to the traceability of specifications and data. An example of this digital continuity: the use of systems engineering methods has been coupled with advances in digital simulations for designing power stations and rapidly making prototypes of new control rooms for reactors. R&D programs figured in a project funded by the Direction Générale des Entreprises (DGE, part of the French Ministry of the Economy). For four years, ÉdF, AREVA, the Atomic Energy Commission (CEA) and the nuclear industry's other partners, such as ATOS, RRCN, ESTEREL/ANSYS or ALSTOM/GE, took part in this project which, in 2014, gave birth to FabLab Connexion. The tools designed during this project considerably reduce the time spent on preliminary studies and will help design new reactors or modify existing ones.

The main purpose of all these R&D innovations is to prepare for the future, to simplify the design and operation of nuclear power plants. Meanwhile, engineers and plant operators have, themselves, come up with many other innovations. For instance, ÉdF's engineering teams have ever more exchanges for the purpose of designing new reactors in line with plant life-cycle management (PLM). The information for equipment specifications is no longer on paper; it is managed in an electronic format. Modifications are thus automatically redirected toward the services that use the data. Since 2015, to cite an example, the management of the EPR construction site in Flamanville (Manche Department) has been digitized, as have been all tests conducted there — all this for keeping the calendar for firing up the reactor. Digital technology is also of growing importance to plant operators: 800 digital applications developed for production in the single year of 2016! Many innovations simplify not only the interventions of work teams at the plant but also the work of managers. Information from rounds at the plant is entered in electronic format; digital "occupational packs" have been made containing documents and computerized procedures; job portals have been opened to decompartmentalize information systems; etc.

How far is it possible, or desirable, to take digitization? ÉdF and the nuclear industry still have to address problems related to; the ownership and governance of data; cybersecurity; the precise amount of value added by digital innovations in comparison with their (often underestimated) costs; and the impact of digital technology on the skills and qualifications of occupational groups.

Digital technology, a new era for energy suppliers and distributers

Electricity grids digitally turned into "smart grids"

Digital technology represents a tremendous opportunity for transforming electricity grids. The recent move toward "smart grids" entails deploying telecommunications and computer technology in order to monitor and control the grids for transmitting and distributing electricity. This technology has been honed during large-scale demonstrations, which have led stakeholders (grid managers, sales forces, equipment manufacturers, etc.) to adopt a joint set of standards. Smart grids will be able to keep abreast with the energy transition. They will be more resilient and flexible for coping with contingencies by, for example, adjusting to the intermittence of renewable energy sources (wind power, photovoltaics, etc.) or instantaneously modulating the demand for current as a function of variations in the price of electricity or the quantity of CO_2 emitted.

For customers, the most visible change is the deployment of Linky. This smart electricity meter will serve to follow much more closely the consumption of electricity. Consumers will have precise information for controlling their consumption. Linky will also be used to design offers of rates that can be modulated over time (beyond the rush and slack periods previously used). The grids will adapt better to customers' consumption patterns and provide incentives for adopting virtuous behaviors. In an act less visible to the general public, connected meters are also being installed in businesses, which did not initially benefit from this offer.

Besides the conventional jobs (electrical engineering, etc.) required for the grids, new skills and qualifications are needed in telecommunications and computer science. The many changes under way in these fields will provide applications for machine-to-machine (M2M) interactions via connected devices and solutions for better supervising and operating the grids, or for coping with looming threats against cybersecurity.

More data, more findings

What characterizes the digital transition is the abundance of data. Besides the data from connected electricity meters, there are the data produced by intrafirm processes or generated by connected devices, not to mention, the open data from third-party sources. Energy suppliers can use big data to optimize in-house processes and offer better customer services. For example, open data have been used to improve predictions of the number of telephone calls from customers as a function of the season. ÉdF answers more than thirty million calls per year, but with very strong variations from day to day. By observing real estate queries (via search engines on the Internet), the firm has been able to foresee the peaks in telephone calls motivated by a change of residence and thus become more responsive to its customers. Thanks to data processing, ÉdF is also helping customers better control their consumption. It has opened websites where individuals, as well as businesses and local authorities, can follow up on their consumption of electricity (and of natural gas): the seasonal trend of their consumption patterns, their intensive uses of electricity; recommendations for curtailing consumption, etc. This advice is increasingly improved thanks to the data from connected devices, the interface between customers and ÉdF's services.

The skills and qualifications required for all this are quite varied: data scientists who process data (for statistics, etc.) but can also extract and manipulate data (informatics); designers and ergonomists who make interfaces that are intuitive and efficient for intrafirm users, customers and corporate partners; etc. Work methods are changing too. Agility is in demand, since innovations can be used to rapidly test insights and prototypes. Work is being organized "transversally" inside the company. Opening toward academic and industrial partners, and toward start-ups, is an indispensable accelerator of innovation.

Digital opportunities for new customer-firm relations

Besides technological innovations, another manifestation of the digital transition is customers' new expectations about their relations with firms. "Horizontal" peer-to-peer relations are overwhelmingly in demand. In Nice for example, ÉdF is experimenting with CityOpt. This application allows customers to form virtual communities (as on the social media) and to name a local association or program as the beneficiary of their efforts for energy efficiency. The value added for ÉdF is to bring people together on a website where consumers enjoy a large degree of autonomy for choosing actions and assigning gains.

On its market for businesses, the company has set up ÉdF Connect Firms, a digital service platform based on the principle of cooperation among business customers, start-ups and ÉdF. The catalog of proposed services is enlarged with contributions from the community. As a function of the needs and expectations voiced by these businesses, third parties (start-ups, innovative small businesses, developers, etc.) propose their services or offer to design new ones. Customers benefit from innovative services; and start-ups, from rapid feedback and improved visibility. Rather than trying to propose all the solutions itself, ÉdF's role is to bring customers into relation with each other by offering them access to a wide range of digital services that respond to their needs.

Connected devices are altering the energy industry's business models

At the end of 2016, ÉdF set up a new subsidiary, Sowee, which offers customers a connected device, a "domotic hub", for their homes. The work of designing, selling and operating connected devices is completely new for ÉdF, which is not a manufacturer. These activities are clear evidence of the opportunities opened by digital technology for the evolution of the firm's business model. This offer has two benefits for customers: by supplying them with both energy and the device for monitoring their heating systems, Sowee enables them to exercise control over both their budgets and their comfort. For instance, a customer sets a budget for heating, and the system will adapt to that setting.

To mention a quite different example: ÉdF is going to install in households "vulnerable in terms of energy" a device that will display in real time (and in euros) how much electricity they have consumed. This system, which relies on Linky, the new connected meter, will help these persons understand their consumption, visualize it in real time and thus exercise more control over it.

The job of supplying energy is going to evolve by integrating a huge number of connected devices in the activities of design, production and distribution.

Digital technology, in particular the IoT, is going to be a decisive lever for the energy transition. The coming of electric vehicles, the installation of solar panels on buildings, the sharing of energy between local consumers and producers… all these trends are going to be stimulated by grid-to-grid interconnections via connected devices and by the exchange of the data indispensable for operating these ecosystems. Smart grids will have ever more connections with other smart things: smart cities, smart homes, smart factories, smart buildings…. Innovations in the realm of digital technology thus create new assignments for energy suppliers. They bring countless opportunities for new customer services and will enable us to exercise increasing control over our energy consumption and to reduce CO_2 emissions thanks to the improved efficiency of nuclear power, the development of renewables and a more effective monitoring of grids and installations at the endpoint of consumption.