Digital technology and the energy transition

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Abstract:
The energy and digital transitions are fundamentally different. The first leads toward a desirable goal (a low-carbon economy and society), while the second should serve economic, social or environmental objectives. The convergence of these two transitions would open tremendous opportunities. Information and communications technology opens new possibilities to everyone (consumers, groups, firms) thanks to the access to information and the emergence of more interactive, flexible and decentralized models for the energy sector. Several problems must be addressed to profit from this technology's full potential: control the energy consumed by digital devices, ensure the security of information systems, set up new value-added services and redefine public and private stakeholders' roles.

Major changes are taking place in the energy sector and digital technology; but a fundamental difference sets these two transitions apart. Whereas the energy transition is moving us toward a desirable goal, namely a low-carbon economy and society, the digital transition is a tool, a means, that must be placed at the service of higher objectives, whether economic, social or environmental.[1]

As recent developments in technology, public policies and private initiatives at the international, national and local levels have shown, the convergence of these two transitions opens enormous opportunities for us, in particular through the mobilization and participation of all parties: firms, governments, local authorities, citizens and nonprofit organizations. The digital realm is providing new possibilities to all these stakeholders by improving the real-time access to a large mass of information and proposing more interactive, flexible and decentralized models.

To profit fully from digital technology's potential, several issues must be addressed. How to control the consumption of energy by digital equipment and applications? How to make digital systems secure? How to create new value-added services? And what role will public and private stakeholders have in this digital society?

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

New digital possibilities for all stakeholders in energy

The tools provided by digital technology mainly rely on the collection and processing of data. All levels of operation in energy systems produce data of interest to all stakeholders.

A successful energy transition depends on improving energy efficiency in the construction industry: residential housing along with the tertiary sector accounted for 45% of final energy consumption in France in 2015.[2] This implies that consumers must better control their consumption. For this, a robust knowledge of consumption patterns and of the levers for acting on them is needed. It could rely on electricity and gas meters that, adapted to households and businesses, measure consumption and display information. By connecting appliances and devices, it would then be possible to control consumption patterns, to make them more flexible through, for example, load management or programmed schedules that take account of the grid's state and other external parameters. Technology evidently amounts to nothing without an adequate socioeconomic approach that takes into account consumers' needs and demands, and facilitates their use of energy while eluding the traps of complexity and gadgetry.

The National Strategy of Research on Energy,[3] adopted by France in December 2016, has emphasized the importance of understanding behavior patterns of "*consum'actors*". It has also drawn attention to the danger of a top-down approach for imposing new technological devices and applications without explaining the potential value thereof and without accepting that all users do not appropriate technology the same way.

If we look beyond the separation between categories (consumers versus producers), we notice that digital technology is tending toward a decentralization as households, groups or organizations "self-consume" the energy they have produced. A regulatory framework has been set up for this. Several legal texts have been published, in particular for applying the so-called TECV Act on the *"energy transition for green growth"*.[4] Tools are necessary to ensure both the technical real-time management of the sections of grids where self-consumption is installed, and the economic management of the current used or supplied through such arrangements.

For energy producers, digital technology opens a vast range of possibilities for optimizing their installations: production forecasts (by using weather forecasts to anticipate the generation of electricity from photovoltaic batteries or windmills), predictive maintenance (statistical analyses for preventing outages or increasing average loading factors), the conditions for grid access (service systems, optimizing the sales strategy in relation to the market), etc.

For grid managers, the digital toolkit can help them optimize grids both globally and variably as a function of time-related constraints. It will help them, for example, to manage: the investments to be made in the infrastructure, the varying supply of current to be uploaded, voltage fluctuations, the messages to send to consumers in an effort to adjust demand, etc. Renewable sources of energy present several challenges to grids that have been laid out in a star pattern around a big power plant, which supplies a constant flow of current. Renewables can benefit considerably from digital technology.

[2] Data from the French Service de l'Observation et des Statistiques (SOeS) are available via: http://www.statistiques.developpement-durable.gouv.fr/accueil.html.

[3] http://www.developpement-durable.gouv.fr/recherche-et-developpement-lenergie

[4] Order n°2016-1019 of 27 July 2016 on the "self-consumption" of electricity; act n°2017-227 of 24 February 2017; and decree n°2017-676 of 28 April 2017. These texts and the TECV Act n°2015-992 of 17 August 2015 are available via https://www.legifrance.gouv.fr/Droit-francais.

For public authorities, the data on consumption, production and transmission over the grid represents, if retrieved, a mass of precious information for evaluating problems, drawing up strategies and planning the most useful investments for renovating buildings, modernizing transmission systems, diversifying the energy mix, etc. It is crucial to be able to process the available data in order to build reliable prospective models and design robust scenarios.

As we see, all stakeholders in the energy transition are caught up in the digital transition. Each of them has a role: use this new technology with discernment.

Digital technology's potential for a low-carbon society

First of all, digital technology represents a challenge in terms of energy efficiency. The ever growing number of data centers, the expansion of telecommunications networks and the massive distribution of connected terminals are exploding high tech's electricity consumption. This consumption must be brought under control by designing smart but sober equipment and devices. Plans are being made, for example, to recuperate the heat produced by the data centers now being built. They foresee supplying the heat to residential areas or office buildings, and limiting expenditures on the energy used to cool the centers. Digital firms, ever more aware of their activities' environmental implications, are actively supporting research on renewables.

To build confidence in digital technology, we must, from the start, see to the security of information systems and data. Cybersecurity of the systems means that it would not be possible to damage or malevolently control installations (whether power stations, control centers or transmission lines) from a distance. Vital energy infrastructures must not be jeopardized by connections to networks that are not safe. Furthermore, since digital technology often allows for a high degree of automation, strict criteria are needed for reliability; and the right level must be found for placing the human/machine interface so as not to reduce resilience or to hamper the capacity for emergency interventions. Cybersecurity is also crucial for the data, which have an economic value and are often confidential.

Beyond the issue of security, questions arise about how to use data for new applications while protecting the legitimate, private and professional, interests of natural or legal persons. Data on energy consumption can provide information about, for instance, a household's lifestyle. In France, the CNIS (Commission Nationale de l'Informatique and des Libertés) is working on a regulatory framework for this sort of data.

For the energy sector to profit fully from digital technology, it is, last but not least, necessary to create new services with a real added value for consumers. Devices for home automation exist for several years now, but simply hooking the most recent generation of connected devices up to the grid will not suffice to reap the expected savings in energy. Big data and smart grids might sound like a magic incantation, but much work is yet to be done to realize full, efficient and truly useable solutions for a real-time smart management of energy networks.

To address these issues, the government is supporting several research and demonstration programs. Since 2011, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie) has put up €120 million to fund forty programs via Investissements d'Avenir. The programs under way are intended to test: islanding portions of the grid to protect local areas from problems on the grid (the Nice Grid program); coupling installations that produce electricity from renewables with those that store the current (for supplying electricity to an industrial park: the Smart ZAE program in Toulouse); and developing tools for managing self-consumption based on blockchains (the Digisol program in the Pyrenees). Regions have been chosen for pilot programs on a larger scale. Some of these programs are now operational: Smile in Bretagne-Pays-de-Loire and Flexgrid in Provence-Alpes-Côte d'Azur.

Public authorities have a role to play as facilitator and catalyst. Opening data can free innovativeness and provide stakeholders with the tools of knowledge for orienting their actions. This motivated, for example, the hackathons, such as the one organized by the Ministry of the Environment in May 2016 on using data from connected electricity meters for the Greentech program.[5] The "state as a regulator" thus coincides with the "state as a platform" for the purpose of making data available (or pushing economic agents to do so) so as to stimulate the creativeness and skills of all parties. In compliance with the aforementioned TECV Act, decrees about opening data sources on energy were issued in the summer of 2016.[6] The Digital Republic Act has also made advances in opening data sources.[7]

The digital revolution at the service of the energy transition in a key sector: Transportation

Transportation is the major source of greenhouse gases in France: 29% of the total in 2014. It is emblematic of how digital technology opens enormous opportunities for the energy transition.

The access to new, massive sources of data about the flows of people and merchandise should, along with an "interconnected" view of transportation's supply-side, facilitate an intelligent planning of investments for urban and rural planning. For example, local authorities will be able to propose, in real time and without outages, new "intermodal" transportation services based on user data. Businesses will be able to optimize their logistics. Consumers will have better access to solutions with a smaller environmental footprint, such as car-pooling and -sharing, thanks to connections via efficient platforms (Blablacar, IDVroom, Drivy, etc.). Connected, autonomous vehicles open vast prospects for optimized driving. Even though major efforts must still be made, it is, in all the aforementioned cases, possible to reduce energy consumption as well as the emission of greenhouse gases and air pollution.

In support of this trend, authorities have drafted the National Strategy for Developing Clean Mobility,[8] which addresses the issues already mentioned herein. Public authorities have a crucial role to play in "freeing" data and bringing all "modes" of transportation to communicate with each other. This means handling the divisive problems sparked by competition.

The need for regulations has emerged to guarantee a secure development of new services, such as connected (and, soon, self-driving) vehicles. French players are on the cutting edge of this trend. Research has entered the phase of real-life experimentation. VEDECOM (Institute for Public-Private Partnership Research and Training for Individual, Carbon-Free and Sustainable Mobility) is backing a public-private R&D program funded by Investissements d'Avenir and two middle-sized firms (Navya and EasyMile) for testing driverless shuttles in Lyon and Paris.[9] To send a clear signal about the prospects to both entrepreneurs and users, the regulatory framework — the highway code, the concept of liability and the technical specifications for cybersecurity in particular — will have to be quickly adjusted.

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[5] During a hackathon, programmers volunteer to work together to invent new applications (*e.g.*, by using a data bank). Creative happenings of this sort are frequently used to stimulate digital innovations. See https://www.data.gouv.fr/fr/posts/compteurconnect-les-donnees-du-hackathon-sur-la-consommation-energetique/.

[6] Decree n°2016-973 of 18 July 2016 on making available to public parties data on the transportation, distribution and production of electricity, natural gas and biomethane, petroleum products, and the products of heating and cooling. Decree n°2016-972 of 18 July 2016 on the confidentiality of the information in the hands of operators in natural gas and of public utilities.

[7] Act n°2016-1321 of 7 October 2016 for a "digital republic" (available at https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000033202746&categorieLien=id).

[8] This strategy, published in October 2016, is available at http://www.developpement-durable.gouv.fr/sites/default/files/Stratégie développement mobilité propre.pdf.

[9] http://www.vedecom.fr.

"Electric mobility" is a technological challenge given the demand for current from the grid. But it could also be a basic building block for improving the operation of grids and deploying a more decentralized management, under condition that managing the load carried by the grid is smart — smart enough, for example, to upload the electricity, if need be, stored in the batteries of electric vehicles. Once again, with the support of Investissements d'Avenir, demonstrations are under way for developing algorithms and communication protocols (for example, Enedis's BienVEnu program for optimizing the recharging of electric vehicles in a residential zone).

Conclusion

The promises and, already, realizations are numerous, as are the prerequisites, the problems to solve and the obstacles to overcome. Mobilizing all stakeholders in the coming years is the condition for reconciling the digital revolution and the energy transition so as to turn tests and demonstrations into environmental, economic and social success stories. It is, therefore, important to continue our efforts in favor of technological, systemic and societal innovations by adapting, in parallel, the regulatory framework to back up this trend and to support, and follow up on, experiments with these new tools before their roll-out on a large scale. To achieve this, several sometimes compartmentalized domains (energy, digital technology, the automobile industry, the transportation infrastructure, insurance companies and NGOs as well as state, local and regional authorities) must be brought to work together.