Scientific
Chronicles Magazine

VEOLIA ENVIRONNEMENT

Issue 18 / Smart grids / September 2010

Research & Innovation

The Lowdown on Smart Grids

Contents

Veolia Environnement, an energy services operator via its subsidiary Dalkia, held jointly with the French power utility EDF, is positioning itself on the future market in intelligent power grids, or smart grids. The smart grid concept is gaining ground fast, driven by changes in the electricity market. Rising demand, a growing use of decentralized means of production, in particular renewable energies, and final consumption control and flexibility are the factors grid managers have to consider. Veolia Environnement researchers are on the verge of developing a project to assess the technical feasibility, value and economic viability of aggregation, which consists of linking a central management station to different sites connected to the power grid, including both consumers and local power producers. The goal is to steer the sites' demand or production capacity by deploying systems for their real-time remote management, to optimize local load balancing and thereby offset the constraints of the centralized production/transmission/distribution system. We take a closer look at the emerging field of aggregation.

INTERVIEW

Murat Isikveren

"In the future, Veolia Environnement will provide services to better regulate power distribution."

Murat Isikveren
Head of Veolia Environnement's Energy and Buildings Research Program
murat.isikveren@veolia.com

What is a smart grid?

"A smart grid is an intelligent power grid. It's not an easy thing to define simply: it is more an idea expected to evolve over time than a specific, well-defined technology. Roughly speaking, it involves a power grid that can communicate, whose different components are linked not just physically, by high-, medium- and low-voltage lines, but also virtually through meters and other communicating devices. The physical power grid is paired with a communication network (see diagram p.3), capitalizing on the development of Information and Communication Technologies (ICT). In line with the principle that we can only control what we can measure, the deployment of communicating meters—also called smart meters—should support more efficient power management."

So a smart grid is a communicating power grid?

"Although communication is an essential part of smart grids, there is more to them than just the use of ICTs to manage the electrical grid. You can approach smart grids from a number of angles, depending on how you envision the power grids of the future: integration of renewable energies, electric vehicles, control of consumer demand, energy storage, power grid upgrading, etc. It is a conceptual revolution, which will affect both production and consumption. It will profoundly alter power grid architecture, which has to become more flexible, and our relationship to power, involving end users directly."

"Smart grids will profoundly alter power grid architecture... and our relationship to power"

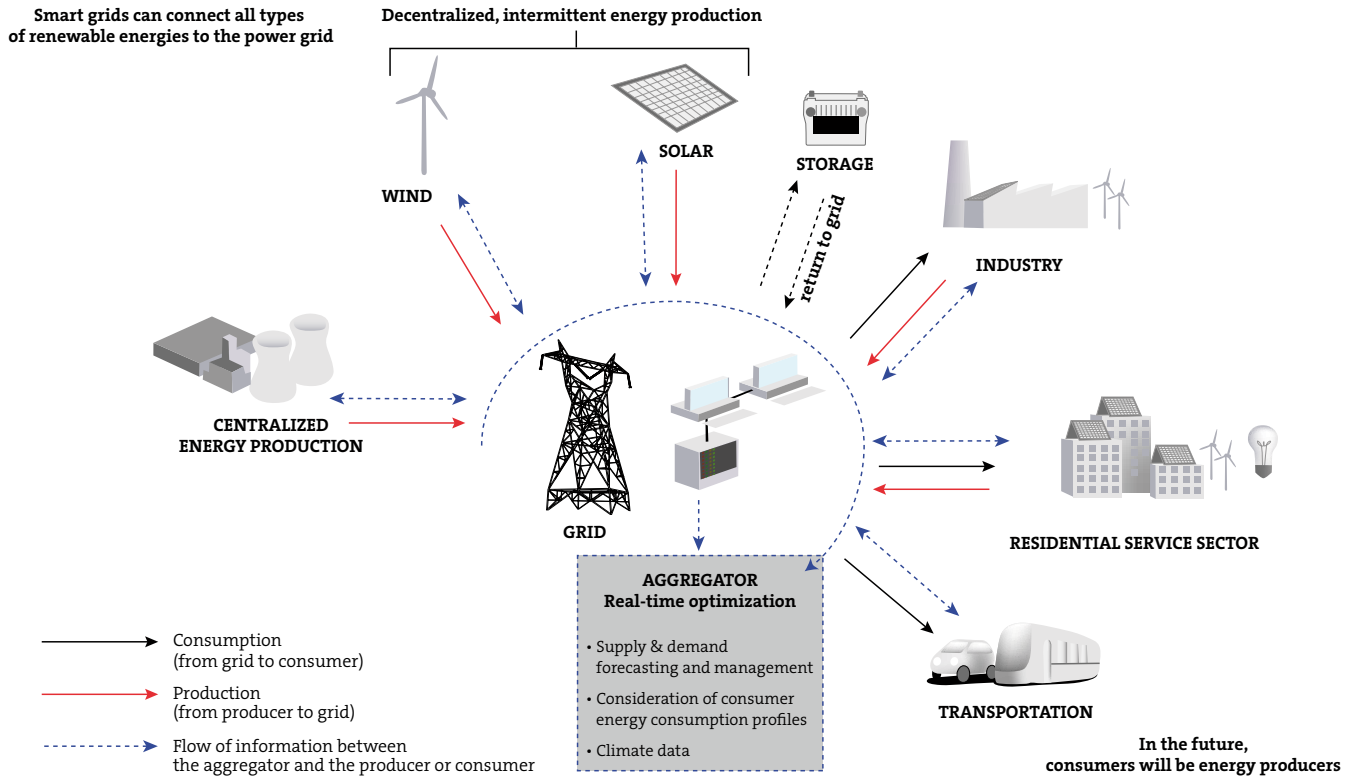
What changes in the power market are smart grids a response to?

"First of all, demand for power is on the rise, not just in emerging countries, driven by demographic and economic growth, but also in the most industrialized countries, because of society's greater dependence on electricity. According to official forecasts, power consumption will increase 50% in the United States and almost 40% in Europe by 2030. It is expected to more than triple in China and India and double globally. So we will have to deal with that increase while maintaining quality of service. In other words, without shutdowns. Most of the world's power grids are built around the same architecture. Power is usually generated in large plants, then transmitted to transformer stations for distribution to end users. There are currently very few power storage facilities (hydroelectric dams, for example), which means power production must constantly equal consumption. The grid operator—RTE and ERDF in France—is responsible for keeping the two in balance."

What happens when they are not in balance?

"An imbalance between production and consumption creates frequency or voltage variations on the grid that can damage electrical equipment. Too great an imbalance causes power outages and failures. This is a troublesome but common occurrence, especially in the United States (see box, p.4). Besides the immediate inconvenience, an outage can have a number of consequences, including damaged motors, impaired equipment, food spoilage, lower productivity, health hazards and interrupted experimental tests. So before we reconfigure power grids, which entails major capital expenditures, we must relieve bottlenecks by managing their flows more efficiently."

Are smart grids smart enough to take steps to protect the environment?



Future power grids will incorporate a number of sources of local and decentralized renewable energy production

"Yes, the environment is the second challenge facing grid managers. In an attempt to combat climate change, renewable sources of energy are growing and now include photovoltaic panels, wind turbines, hydroelectric micro-dams, turbines in wastewater treatment plants and waste treatment centers, etc. Originally designed to move power in one direction, from plants to consumers, current grids do not support the massive deployment of these new sources of power production scattered across the country. Especially since they often operate intermittently (wind, solar) and are thus hard to control, which creates problems balancing the grid. Smart meters and weather forecasting tools will help us predict their production and therefore facilitate their integration."

What about reasoned demand for power?

"The growing scarcity of fossil fuels and the need to curb greenhouse gas emissions create a push to cut consumption and control the demand for power. This initiates a change in user behavior. Users become producers of power for their own needs, by means of micro wind turbines, photovoltaic solar panels, etc. They can even resell their surplus production (positive energy buildings, for example) or their reduced consumption (voluntary curtailment, offloading). By providing access to information, the smart grid will make this kind of interactivity between end users and the grid possible. Better control of consumption should be the result."

What kinds of research does Veolia Environnement plan to do?

"We are in the process of setting up a regional project to assess the technical feasibility of aggregation, estimate the potential gains in terms of balancing power production and consumption and limiting consumption, evaluate the viability of different economic models' and think about how to set up the stakeholders' system for smart grids. The experiment will deploy solutions for managing power production, storage and usage in 20 buildings, including commercial and office complexes, a treatment plant, solar power plants, storage facilities (fuel cells, hydraulic plant, thermal storage, battery storage, etc.) and drinking water pumping stations. We will look

"Current grids do not support the massive deployment of new sources of renewable energy scattered across the country"

Line losses: 7% to 16% of the power produced

Transformer stations are usually located about a hundred kilometers from power plants. As a result, some of the energy produced is lost as heat in transmission lines. Line power losses are proportional to the intensity of the current in the power lines. However, at a constant power level, reducing intensity amounts to increasing voltage: that is why transformers on the way out of plants ramp up the voltage (225 and 400 kV for France's very-high-voltage grid) and other transformers gradually lower it as the lines get closer to the end consumer (15 and 20 kV for the medium-voltage grid, 220 and 380 V for the low-voltage grid).

Power failures: a global phenomenon

Power grids in the United States are undersized in relation to demand and often saturated. A study[1] showed that despite capital investments by power companies, power failures did not drop in frequency between 1984 and 2004 and have even increased in the last few years. The existence of intermittent energy sources such as photovoltaic panels and wind turbines have made the grid more unstable. Wind turbine systems in particular cause disruptions when they stop operating because of too-heavy winds and disconnect from the grid. Another study, conducted by the Lawrence Berkeley National Laboratory, estimates that power failures cost the United States $80 billion a year[3].

The U.S. is not the only place to suffer outages: in Europe, nearly four million Danes and Swedes remained without power for several hours in 2003 following a failure. Wind turbines were blamed for the November 4, 2006 blackout in Europe (wind power accounted for 40% of German production at the time of the incident)[4]. The biggest failure occurred in Indonesia and affected 100 million people, while India's economic growth is being handicapped by very frequent outages[5].

(1) Based on data from the U.S. Department of Energy (DoE) and North American Energy Council (NERC).
(2) Hines et al, 2006.
(3) La Commare & Eto, 2004.
(4) Merlin & Desbrosses, 2008.
(5) India Core, 2005.

at how they smooth the called load in the regional distribution grid and the resulting environmental impact."

What exactly are you going to be working on?

"Four areas of focus are planned. The first is consumer infrastructures: we want to predict their energy behavior and determine their potential to create flexibility. The second has to do with production and storage infrastructures: we're going to study the flexibility provided by local storage facilities and the monitoring of decentralized power production. The third part of our research project concerns aggregation per se: it looks at the communication infrastructure and software solutions to be deployed to retrieve and process the data from the different sites, for optimal flow management. The fourth and last area involves economic, environmental and sociological studies."

What is the role of Veolia Environnement's research team in this project?

"We are responsible for coordination. In general, we will concentrate on developing forecasting models. We want to be able to predict power usage one or two hours or several days down the road. For example, we're trying to determine offloading strategies based on demand for power and other factors. We're also doing financial modeling to figure out the business model that will enable the smart grid to be integrated into the current market. We're also studying feedback on already existing technical solutions. Finally, we're interested in smart grids' environmental and social impact: analysis of system life cycle, acceptability by users and the market's various stakeholders and so on." ■

Power consumption is expected to increase 50% in the United States and almost 40% in Europe by 2030. Unless the grid is optimized, power failures will be increasingly common.

TECHNOLOGIES

How to Create a Smart Grid

Developing smart power grids will require a slew of technological innovations, notably in the field of power storage. We also need to think about the framework in which smart grids can be set up.

The research required to make smart grids a reality starts with grid equipment and electrical engineering: designing sensors to collect data on the energy consumption of all buildings, shutdown devices, protection systems, etc. Information management innovations are also needed: processing billions of pieces of data in real time will take communication standards and interfaces enabling the data to travel between the grid's different components. To manage power distribution, specialists will also need to develop forecasting tools—for production and consumption—and operational and monitoring resources. Finally, breakthroughs are needed in decentralized storage technologies. We especially need to better understand how storage devices age and to optimize charge and discharge cycles.

A network of partners

Veolia Environnement's research department works with several partners, university teams and manufacturers with solid expertise in the issues raised by smart power grid deployment. They include automatic control technology specialists, to manage information and monitor energy systems; specialists in communication, metering and energy management solutions; Institut National de l'Energie Solaire (INES), a leading research institute in the field of solar energy integration; and École Supélec, a major player in power grid research.

Inventing new frameworks

"Besides technological innovations, we also need to think about the technical, socioeconomic and organizational framework in which smart grids can

Electric vehicle

Although the deployment of electric vehicles will sharply boost demand for power, recharging their batteries at night should prevent spikes in demand. Moreover, the batteries of the millions of electric cars can serve, when they are parked, as usable storage devices during peak demand periods.

be set up," explains Eric Nicolas, a Smart Building expert with Veolia Environnement's Research & Innovation. "We have to create new economic models and/or draft a regulatory framework that is flexible enough to leverage the full potential of local power production and that defines the roles of the different stakeholders involved in smart grids. We must also study the social acceptability of the new products and services smart grids will create and highlight the factors likely to make households behave as if they are stakeholders in the system, notably in terms of controlling their energy use and driving electric vehicles." ■

"We need to create new economic models"

Modern office building

Buildings need tools (similar to those used by smart grids) to regulate their own energy use based on their exposure, occupancy, weather conditions and renewable energy production and storage capacity. Specifically, they need sensors and information and communication systems to measure, detect malfunctions and activate equipment such as blinds, heating or air conditioning systems and so on. That is the job of centralized technical management, a field that makes buildings smart and already boasts quite a bit of equipment. The goal now is not just monitoring, but management, including offloading, adjustment of heating curves, etc.

Power storage: a major cog in smart grids

To better regulate power distribution, operators need to find a way to store electricity during off-peak periods—so as to supply only the power needed—and to use buffer stocks during peak demand. "Storage helps balance and stabilize the grid; it makes transmission and distribution facilities more efficient and allows you to integrate renewable energies," says Eric Nicolas, smart building expert with Veolia Environnement's Research & Innovation. The power sector is one of the few industries that has no systematic storage system. Yet efficient solutions have been developed in the last few years that are good enough to be deployed commercially. Various storage options exist, for households (electric vehicle batteries, hot water tanks), buildings (thermal inertia, photovoltaic panels) and communities (hydroelectric dams, water towers). "Now it's time to organize the storage system on a larger scale," explains the Veolia Environnement researcher. "It is an essential piece of the puzzle for adding flexibility."

THREE QUESTIONS FOR...

Bernard Saint-André and Jean-Philippe Laurent

"Our skills and expertise make the aggregator field a natural fit for us."

Bernard Saint-André
Dalkia Executive Vice President, Strategy
bsaintandre@dalkia.com

Jean-Philippe Laurent
Dalkia's Marketing Director
jplaurent@dalkia.com

What services will Dalkia offer to make power distribution grids smart?

BSA : "In the future, Dalkia will act in a new professional capacity, that of aggregator, which will be added to the gamut of environmental services provided by Veolia Environnement. Aggregators are intermediaries between the power system and users (individual households, multifamily housing, manufacturers, commercial and office buildings). Their role is to optimize the operation of as large a group as possible of buildings or commercial/office and industrial sites in terms of their immediate power demand, to get them involved in keeping the power system in balance.

JPL: For example, aggregators will offload some of the power uses of buildings they manage or start backup generators available at other sites during peak periods of demand on the grid. They therefore generate local flexibility and create value for Dalkia and our clients by selling that flexibility to the power system. Such flexibility is sometimes called a "virtual power plant." To function in that role, an aggregator needs to make the buildings and sites it manages "intelligent", in order to have the information and resources it needs to manage its equipment in service from a central system control hub. It also needs to write software to model the building's reactions (heating, for example) to various situations, so that it can operate while maintaining a minimum level of service. Finally, aggregators must have information systems that can forecast the grid's future situation and leverage the availability of power created. So it's an entirely new field for Dalkia that requires quite a few R&D developments.

Aggregation is based on ICTs. What makes Dalkia well-situated to position itself in this new field?

BSA: "It involves integrating new information technologies into the energy services sector in which we are a major operator. Dalkia already runs a large number of decentralized energy production facilities, supplying buildings, hospitals, districts or cities and industrial sites. So we have long deployed information systems for remote management at certain facilities. It actually involves continuing down the same road in order to deploy much more sophisticated tools, using principles in which we are already quite proficient.

JPL: Dalkia also has recognized expertise in optimizing the energy management of buildings, under contracts specifying performance goals. On behalf of our clients, we are already active in energy markets as a seller and buyer. In addition, Veolia Environnement is a flow manager in its four environmental services fields of water, environmental services, energy and transportation. Our skills and expertise make the aggregator field a natural fit for us. Obviously, we work with competent technical partners."

What kinds of aggregator services does Dalkia offer right now?

BSA: "They are an essential extension of our current services. Dalkia offers demand management services in the United States and is experimenting with projects in France. Our offer foreshadows the energy services of the future." ■

*"We have to integrate **new information technologies** into the energy services sector"*

This Scientific Chronicles Magazine supplements the Video.

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Photos: The VEOLIA photo Library – Justin Sutcliffe - Polaris/interlinks Image, Christophe Majani d'Inguimbert

Acknowledgments:
The editorial team would like to thank them for their time and contributions.

Chief Editor and Editorial Manager: Fanny Demulier
Editor: Xavier Dorveaux
Copywriting: Monik Malissard
Design: Dream On
Contact: Communication Department for Research & Innovation
19 rue La Pérouse
75016 Paris - France
Tél.: +33 (0)1 71 75 10 88
Fax: +33 (0)1 71 75 05 92
Mail: fanny.demulier@veolia.com
Mail: xavier.dorveaux@veolia.com