SMART GRIDS

Power grids have long been constructed with a built-in intelligence. So why is so much noise being made over the arrival of so-called "smart grids"? Are we witnessing a real revolution? In a clear departure from the past, more and more flexibility is being demanded from the existing infrastructure, largely as a result of development in renewable energy sources. Solar and wind power are intermittent and can lead to rapid fluctuations in production. Another factor is the desire to create a more dynamic infrastructure to better cope with fluctuations in demand without the need for investment in further plant construction. To create grids capable of meeting the challenges more flexibility is required and can be provided by adding new forms of intelligence. The potential for a massive shake-up is clear, one that could have an impact on power utilities, regulators, manufacturers, network managers, and consumers for many years to come.

Since inception, electricity generation has required intelligent networks. In the beginning, when power was a strictly local affair, networks were operated with the aim of controlling the frequency. In short succession, links were created between different grids in order to provide greater security and reduce the cost of electricity. The excess capacity of the hydraulic installation in one region could be used to prevent the need to fire up the turbines of a thermal power station in another producing carbon savings for all. Interconnectivity and mutual dependence combined to create greater reliability. Networks, by design as well as definition, became increasingly complex which led to the development of a sort of "intelligence" that has become more sophisticated over time. For evidence of this evolution we need merely cast a glance at the state-of-the-art in system design in terms of security and transmission lines. Given the risks associated with higher voltages (breakdowns at 400 kV are rather more serious than those associated with lower voltages) it should come as no surprise to find that the level of sophistication rises along with the level of voltage. Indeed, the present networks are a natural reflection of a careful balancing act between the benefits of built-in intelligence over the costs associated with constructing a supplementary communications layer.

Without this built-in intelligence modern networks could never meet the current demand. The idea of intelligent networks therefore did not arrive yesterday.

The current outlook on power grids is shadowed by two considerable clouds weighing just on the horizon: a lack of investment and the increasing role of renewable sources of energy. These two elements have heightened the need for greater flexibility in getting electricity where it needs to be.

These two challenges will have a huge impact on determining whether power grids can evolve at the required scale.

The first challenge is the level of investment required.
Investment in electricity generating infrastructure is entering a major growth phase. In emerging economies such as China investment will be required just to keep pace with demand and is projected to approach 200 billion dollars for the period 2010-2020.

In more developed countries the sums demanded are still colossal, even when making estimates based on a low annual growth rate of 0.7%. Existing infrastructure is aging and needs to be updated, a process that is made more urgent by new environmental regulations (coal plants). Europe witnessed 540 billion dollars of investment in the period from 2000-2010 and according to one scenario (from the IAEA) could see $1.136 trillion for the period 2010-2020.

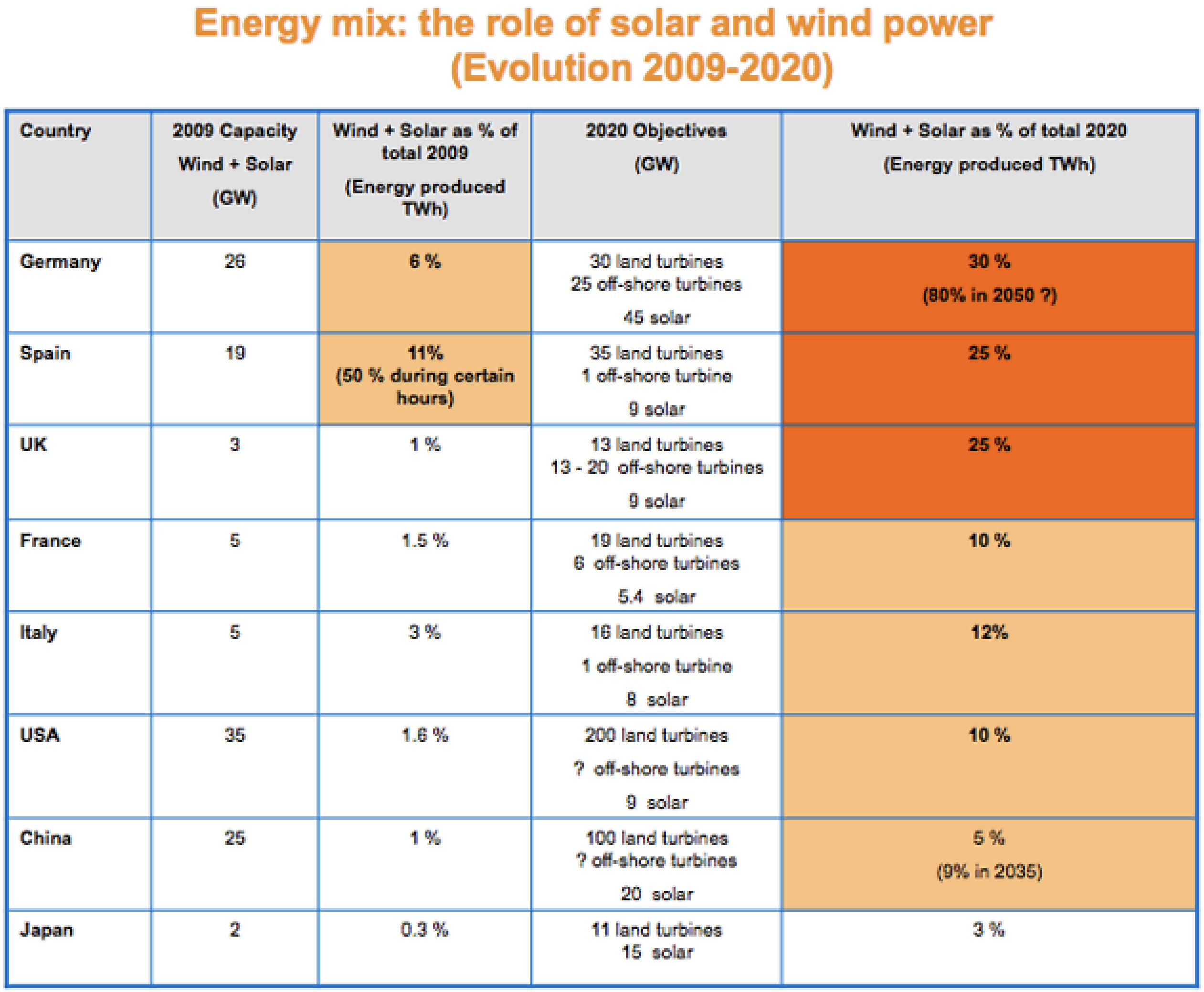
With such huge stakes the natural tendency has been to limit spending only to what is strictly necessary. Many have chosen to favor a process which weighs the benefits of investment in infrastructure and attempts to balance them by reducing demand, especially during peak periods when the grid reaches saturation point. This has certainly been the case in France where at the initiative of Marcel Boiteux dynamic pricing was introduced to encourage consumers to adjust their consumption habits to favor off-peak hours. Under current conditions the policy has excited renewed interest but to fully harness its power more flexibility will have to be added, specifically at the level of demand.

The second challenge is to significantly increase the role of renewables in power generation.
Under one scenario provided by the IAEA, Europe could raise the contribution made by renewables by as much as 30% by 2020 through the efforts of countries like Germany where plans are afoot to boost this figure to 80% by 2050. Fears over greenhouse gas emissions have provided the political will to make such statements and rapid progress is being made.

When making a distinction between renewables and more traditional energy production methods two points are key:

- they are often intermittent (wind, solar),
- they demonstrate more geographic variation than conventional sources of energy. Either they are located far from major population centers (off-shore wind farms or deserts for solar arrays) or are actually integrated into living environments (solar roof panels and micro-wind turbines).

The massive arrival of intermittent renewables (wind and solar) will undoubtedly create stress on the current infrastructure unless flexibility is sharply increased. This could be accomplished in a number of ways. One idea is to build more traditional power stations to pick up the slack when intermittent supplies are absent. Another is to create energy storage devices (batteries, hydraulic accumulators, balloons for storing hot water). Going another route, more flexibility could be created on the demand side (limiting supplies when the wind disappears and easing up when it starts to blow).



Energy mix: the role of solar and wind power (Evolution 2009-2020)

Country	2009 Capacity Wind + Solar (GW)	Wind + Solar as % of total 2009 (Energy produced TWh)	2020 Objectives (GW)	Wind + Solar as % of total 2020 (Energy produced TWh)
Germany	26	**6 %**	30 land turbines 25 off-shore turbines 45 solar	**30 %** **(80% in 2050 ?)**
Spain	19	**11%** **(50 % during certain hours)**	35 land turbines 1 off-shore turbine 9 solar	**25 %**
UK	3	1 %	13 land turbines 13 - 20 off-shore turbines 9 solar	**25 %**
France	5	1.5 %	19 land turbines 6 off-shore turbines 5.4 solar	**10 %**
Italy	5	3 %	16 land turbines 1 off-shore turbine 8 solar	**12%**
USA	35	1.6 %	200 land turbines ? off-shore turbines 9 solar	**10 %**
China	25	1 %	100 land turbines ? off-shore turbines 20 solar	5 % (9% in 2035)
Japan	2	0.3 %	11 land turbines 15 solar	3 %

Managing the need for flexibility: making the grid smarter

Worries over whether investment is being structured intelligently and increases in the use of clean-energy technologies are placing strain on electricity grids to deliver enough flexibility, especially in relation to demand. Whether development occurs on the existing infrastructure or through the creation of new technologies the need for action has become urgent.

To integrate this flexibility successfully a new approach toward managing networks is being traced out. One that encourages a new approach to peak-hour demand by, for example, urging customers to put off the laundry until after supper or setting up manufacturing to correspond with the operation of wind turbines.

In order to manage this new logic of supply and demand in the electricity grid what is needed is a large dose of intelligence. Whether at the European, national, or local level stakeholders need to look at each level of the system and the constraints lying in the path of more successful integration.

To accomplish this massive task will require a radically new mindset as up to the present, the ebb and flow of energy was for the most part managed by large centralized power generation facilities. In the case of France, this has meant reliance on large nuclear power stations as the most efficient way to ensure adequate energy supplies following spikes in demand. Yet as mentioned previously, more flexible networks demand more flexible responses and these can only arise when various actors are working in unison at all levels of the production chain. Looking at a low voltage network, connected individuals could make use of communications networks and information systems to harness the power of small electronic devices (using powerful chips, internet protocols, intelligent meters, photovoltaic controllers for roof-mounted panels, etc.) capable of relaying information, and allowing for more agile responses to local and national energy demands. The significance of this change cannot be underestimated as the current grid is largely a one-way street and, while perfectly capable of delivering energy, without improvements will be largely incapable of responding to the new demands.

Without the necessary flexibility the massive development of renewable energy will reach an impasse which is why an intelligent network has become so essential : a smart grid.

The emergence of smart grids entails innovations representing a sharp rupture with past practices in three primary domains:

- technical and technological
- the role of customers in the electricity grid
- industrial policy

A rupture in techniques and technology : a novel approach to networks and the path ahead to the devices that will mark the new grid (storage, …)

The early stages of development will unfold at two ends of the production chain, impacting on high voltage networks at one end and low voltage networks at the other.

High voltage networks have benefited from developments in High Voltage Direct Current (HVDC) technologies and are absolutely essential in the transmission of electricity from off-shore wind farms and solar installations in faraway deserts. Along with the fact that the technology can at times represent the only possible solution, such as with the connection running under the Channel linking England to France, it has also demonstrated remarkable cost efficiency running underground when compared to overhead lines using Alternative Current (AC) once distances of 600-800 kilometers are surpassed (this is due largely to the fact that only two cables are required instead of three which mitigates the cost of converter stations). The entire domain is ripe for development and represents an important element in the future of high voltage networks.

At the other end, it is in the distribution networks that some of the most meaningful developments are likely to occur and this is due to a number of reasons.

These networks have been connected to renewable energy producing devices (notably rooftop solar arrays) although they were never designed with this usage in mind. Questions over voltage regulation and an adequate system of safety and assurance require a response. Currently, in the south of France, issues over the interaction between photovoltaic installations and the high voltage network have led to the devices being disconnected altogether during certain periods.

Customers connected to the low voltage distribution network will need to see more flexibility if the promise of the system is ever to be realized and at present the infrastructure has come up rather short.

An investment in research and development is required and this has become a growth area as demonstrated by the number of industrial pilot projects launched worldwide (around a dozen in France alone). The fruit of the research should create networks that bear little resemblance to the ones in use today.

With the transformation of the energy value chain a number of innovations should begin to appear across networks, particularly in terms of storage devices where R&D is occurring at a feverish pace. Electrochemical storage is promising for both large capacities, with NaS batteries (sodium sulfur) installed at the source or on a more modest scale (lithium ion) to be distributed to customers. Research and testing is also taking place using compressed air energy storage (CAES and adiabatic CAES). The picture is rounded out by technologies that harness energy in forms that can later be used to either heat or cool (by for example, creating ice when energy is cheap and abundant to cool the grid when it is not, such as when wind turbines slow down).

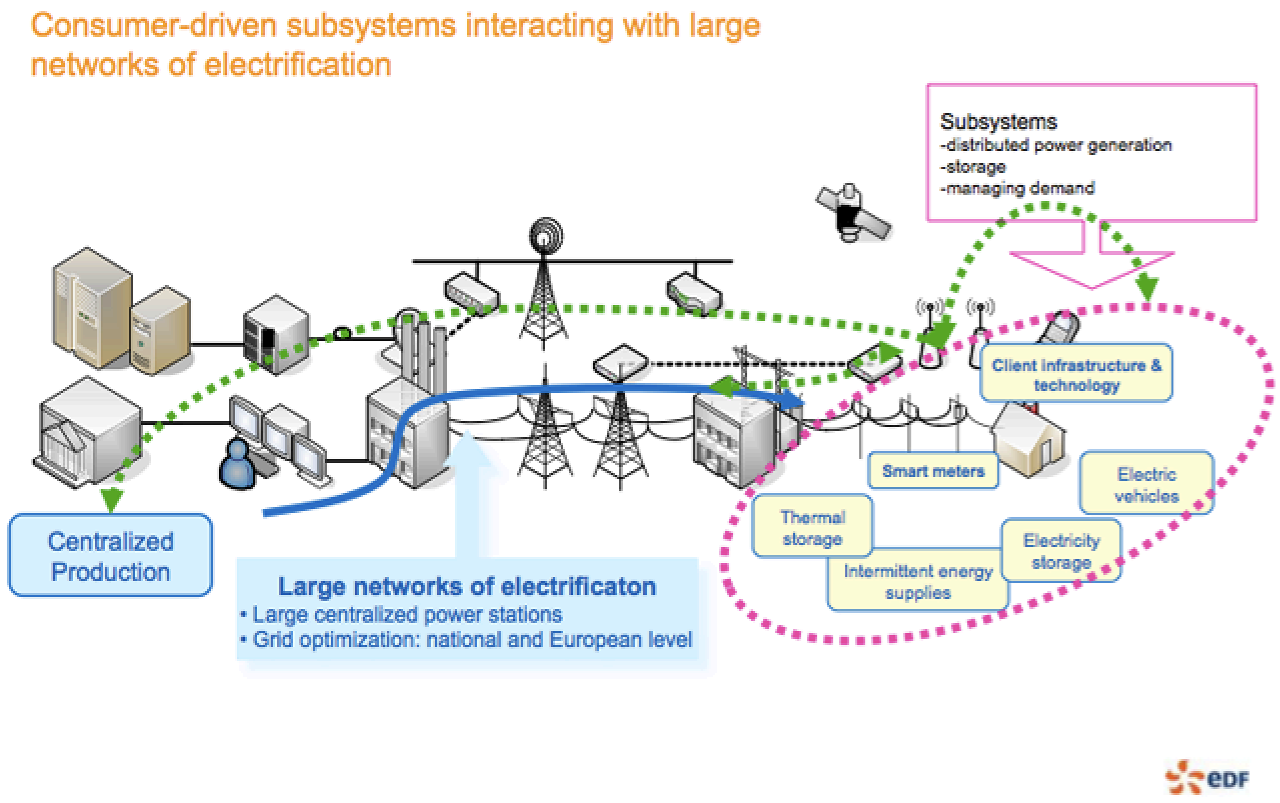
A rupture with the past and the evolving role of the customer at the heart of the grid: the transition from passive consumer to partner in energy production. Are we witnessing a break with previous roles in the relationship between utilities and their clients?

As the energy value chain becomes increasingly flexible and undergoes a process of decentralization, the customer is becoming more of a partner in the system. Individuals can wear many hats, taking in power generation (rooftop PV) as well as storage (using electric vehicles), and can modulate demand according to need (using accumulators of hot water balloons or a dual-energy heating system using for gas and electricity for example).

Consumers contribute at a number of levels and spread generating capacities across the entire spectrum of demand and/or lift any restrictions due to limitations on regional or local infrastructure. Moreover, they allow for more efficient management of spikes in demand and offer the possibility for a rapid response (by lowering consumption in real-time following a temporary outage at a power station for example).

And yet, while the dimensions of individual consumers may allow them to respond flexibly in the general sense of the term, creating a truly intelligent network in which each actor plays a role, creating the critical mass to harness the true power of the grid, will require a more unified vision in which the various actors are working together.

Energy consumers will have to get together, or allow themselves to be placed, in various subsystems in order to create real gains in efficiency. From this point on, the focus will be to create robust points of interaction between these newer subsystems and the backbone. It’s a process that’s already well under way.



The manner in which these subsystems are composed will play a crucial role in the future.

We have a fair idea of what these might look like :

- a subsystem for those using dual energy heating systems
- a subsystem defined by region
- a subsystem made up of the various sites of a given enterprise
- a subsystem made up of the customers of an aggregator (US market exists).

The actual results will depend largely on regulatory standards and the dynamism of the different stakeholders. The strategic dimension of the questions that need to be asked of the various actors will lend the discussion a defining role in the future outlines of the sector.
What is certain is that the enduring division between power generators and their customers is about to be modified.

And it is on this point that the rupture created by the arrival of smart grids will likely have its most profound repercussions.

What should not be forgotten however is that the changing relationship requires the availability of a reliable communications layer in order to facilitate the new mode of peer-to-peer information exchange on which the entire system depends.

Viewed through this lens, research and deployment of smart meter systems becomes an essential ingredient to the success of the project.

The regulatory framework will also play a major role. We can see for example that an investment in smart metering systems plays a dual role creating a value adding partner for utilities as well as network managers. Regulation has a major hand to play in creating conditions to encourage the kinds of investment that can be of benefit to the wider community.

In the same spirit, regulation can contribute to the construction of a framework that rewards the emergence of technological innovation.

Evolution and rupture in the industrial sector: defining standards and encouraging innovation in electrical engineering firms

Injecting this “new intelligence” into dumb wires will not come cheap and significant investments have already been made (the Obama administration has begun to dole out the $3.4 billion in funds earmarked for smart grid development). The most important beneficiaries will be technology manufacturers (meters, …), developers of software applications and services, and the communications layer.

One possible stumbling block could arise from the notable absence of any common norms and standards. The basic building blocks of the system will remain expensive until large manufacturers are able to create a broader market which in theory should be possible given that the question of how to integrate renewables is truly global. Clearly, agreed upon standards have become a necessity.

Creating shared norms will become indispensable in the rush to create innovation. It will also play a large part in ensuring development costs are recouped through sufficient economies of scale. Standards are indispensable if smart grids are to achieve their true potential.

Conclusion

Reducing the carbon footprint and meeting the energy needs of the future has led us to increased reliance on renewables but an optimization of investment requires networks capable of managing an increasing range of responsibilities; a large dose of intelligence and the emergence of a smart grid.

The challenge to the electricity sector is immense.

The challenge is no less daunting for manufacturers (electrical engineering firms, software developers) as what is demanded is not just innovation but an entirely new set of standards.

Finally, the challenge leads to the regulators as it is they who must:
- create a dialogue between the stakeholders (utilities, network managers…) and create the conditions necessary if investment is to benefit the wider community,
- construct a framework that rewards technological innovation.

Source : http://www.paristechreview.com/2011/07/07/smart-grids-less-carbon-more-intelligent-networks/