SMART GRIDS: AN OPPORTUNITY TO MODERNIZE THE DEVELOPMENT OF DISTRIBUTION NETWORK

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ABSTRACT

Smart grids are today considered as a major challenge for electrical utilities. They are an opportunity to prepare the electrical grid of tomorrow by implementing new functions:
- integration of decentralized and dispersed generation
- demand side management often linked with real price rating
- making the customer an actor of his own consumption.
But smart grids open the path for other services. One of them is focused on asset management, specially for underground networks.
The services for asset management are oriented in 3 ways:
- a better planning system thanks to better load measurement: using smart meters and sensors to model the grid more accurately,
- better real-time knowledge of the power flow to control the network with little margin but with a lower risk of overload, so better efficiency
- real added value in determining the life expectancy of old assets,
The implementation of a new network is the best moment to define technological improvement in order to upgrade the performance of the global system. Underground networks are nowadays the ones that derive the most benefit from all these improvements.
The presentation will provide an overview of the concept of smart grids and the services they generally bring, and will focus on the benefits for underground networks.

KEYWORDS

Smart grids, services, underground networks.

INTRODUCTION

Smart grids equipped with smart meters are being discussed worldwide at conferences on distribution networks. So much so that a good many professionals are wondering whether it is a just a fad or a genuine development in distribution networks.

In fact, new technological opportunities are now presenting themselves, which alter the systemic view of the network, at a time when new needs are emerging both in terms of energy policy and of services for the final customer. It is the conjunction of these two approaches that defines this new concept: smart grids. This is an opportunity to modernize for all network operators confronted with extensive renewal or infrastructure reinforcement programmes.

NEW TECHNOLOGICAL OPPORTUNITIES

Hitherto, the electrical distribution network was essentially a power grid, simple and robust, with a minimum of complex systems, functionally limited to transmitting upstream energy (therefore a transmission network) downstream (therefore to customers). This robustness was linked to the size of the infrastructure whose reliability needed to be guaranteed, which often requires simplicity.

Gradually, new functions were deployed: remotely controlled network circuit-breakers and switches, automation systems to limit supply disruptions for customers when incidents occur, remote network monitoring systems to reduce their running costs.

The development of electronic meters in the 1990s triggered a big change in the network by enabling massive decentralization of intelligence. Combined with a remote meter reading system these meters, which are now economically competitive with the traditional electromechanical meters, in addition offer considerable potential for new functions: remote meter reading, remote programming of metering, changing tariff virtually in real time, information on the characteristics of the supply point (stability of voltage, quality, etc.), new customer services. Many experiments were carried out in the 1990s and the 2000s but did not lead to mass industrialization because of the heavy investment required and uncertainty about the benefits.

All these developments have changed the electric network into a system with 3 levels used in combination and in strong synergy:

- a traditional power grid
- a communication network between key points on the power grid and a centralized command and control system

- a computerized processing and supervision system

Each of these 3 levels involves major challenges:

- the power grid is not undergoing a technical revolution. Superconductivity in distribution will not be deployed in the near future and burying techniques for medium and low voltage systems have been fully mastered for twenty years or so. But the ageing of the oldest facilities, in particular those built in towns when they were first electrified, makes optimized renewal a major challenge, in an environment where it is often difficult to build new structures. Anything that allows structures to be used close to their operating limit for their foreseeable life span is essential. Hence the importance of real-time supervision based on decentralized sensors. Better knowledge of the network also reduces losses, which is an objective all network operators aim for. An important point however should be emphasized: the challenge of decentralized mass electricity storage facilities. The first industrial facilities (large batteries) are being deployed in the United States. This development would make the distributor a key player in balancing supply and demand, a task that currently is almost entirely borne by the transmission network manager.

- The communication network is the key to modernizing the electrical system. It can now draw on a variety of technologies: dedicated lines, carrier currents (using the electrical conductor to transmit signals), short-range radio, microwave beam, optical fibre…It allows one to connect multiple network sensors to a central point. This can only be done by sharing these resources for the benefit of as many applications as possible and by combining the various transmission media as judiciously as possible.

- The processing and supervision system obviously benefits from major advances in computing but the challenges are also huge:
    - o The right balance must be struck between centralization and decentralization of intelligence: is it better to pre-process information rather than developing it to reduce the complexity of centralized systems, at the risk of losing scalability, or on the contrary should one centralize to better handle changes?
    - o how to avoid poor performance when swamped by the mass of data that the supervision systems will produce and that needs to be processed?
    - o what level of integration should be sought, both in functional terms (put everything in a single system or in several ones) and in geographical terms?

NEW REQUIREMENTS FOR CUSTOMERS, MARKET OPERATION AND ENERGY MANAGEMENT

Familiarization with technological challenges will be boosted by the increase in importance of new and very diverse needs, but characterized by virtually simultaneous emergence:

- the high growth in the number and power of decentralized generating facilities in many countries (from a few kW of photovoltaic power to several MW of wind power, not forgetting all the other technologies: biomass, small hydro-electric facilities, etc.) radically modifies the functioning of the distribution network. We are moving from a unidirectional network to one in which energy can flow in either direction. This creates a need for information, modifies the control systems and induces new needs for monitoring the balance between supply and demand insofar as many of these new generating technologies are not flexible but known as fortuitous. Here we obviously see the potential coupling with storage techniques that can give this production more manageable availability characteristics.

- The energy challenges highlighted more particularly at European level require one to give the customer new tools for controlling consumption. The new meters provide the opportunity for providing customers with information in real time to help them in their energy choices. We see here how one could create a coupling of availability of decentralized energy (in windy periods for instance) and the certain customer patterns, which can in part be time-shifted (domestic electrical appliances, heating), via a pricing signal for instance.

- The new face of the electricity market in many countries has created new needs: the option of changing supplier easily, the possibility of making assessments of a supplier between what it has injected and what customers have used. This requires information gathered in real time then aggregated and forwarded to the system's actors.

- Customers always expect better quality of supply: fewer failures, shorter disruptions along with more information on what is happening.

Advances in automation and supervision systems offer interesting solutions, as does knowledge of the electrical needs of each customer, thanks to the signals transmitted by the meters.

- The growth in environmental pressure is forcing network operators to optimize their networks: limit new structures therefore use existing ones better. There again, instrumentation can help. For instance, maximum acceptable instantaneous intensity in an underground cable, determined according to the actual temperature of the subsoil (therefore of the cooling) is much higher than that determined in principle according to a benchmark temperature.

- New practices can completely change the use of the distribution network: the most striking example is the use of the electric vehicle. If there is a boom in them, this will raise two questions: how to develop an infrastructure of recharging facilities in the public domain while limiting the creation new civil engineering structures? how to put daily modulation in the current load curve to better use, and thereby recharge vehicles at the best time to limit the impact on peak demand?

SO WHAT EXACTLY ARE SMART GRIDS?

It is indeed through the meeting of these technological opportunities and these needs that good ideas find applications for them and that identified needs can be met by available solutions.

If we speak about smart grids rather than a series of independent projects, it is because the coming together of all these elements at the same time presupposes a revolution rather than an evolution.

Yesterday numerous projects had difficulty materializing: difficulty in finding true earning power, dissipation of efforts.

Today, with the concept of smart grids, the aims is to seek synergy between all these projects to coordinate developments, use resources to best advantage and thereby make the offer more competitive. That is how these networks become intelligent.

In order to federate all stakeholders on a shared concept, the European Union has carried out collaborative work with them all to define the services and functionalities that smart grids should offer[1]. Six high-level services have thus been identified:

1. new requirements governing access to the grid
2. improved operational efficiency
3. safety and quality of service
4. better planning of investments
5. improved functioning of the market and of customer service
6. involvement of consumers

That list clearly shows that the benefits expected from smart grids are focused on one hand on the efficiency of network management and on the other hand on direct services for customers. However, we must not forget that network management improvement also represents a benefit for the customer.

Smart grids is more an approach than a limited project, because of the continuous evolution of technology and of customers expectations.

That must be taken into account when launching such an initiative.

CONSTRUCT DISTRIBUTION NETWORKS WITH "SMART GRIDS" IN MIND

These smart grids can only be deployed by investing heavily:

- installing a telecommunications network,
- installing remote control systems, in-line sensors,
- installing remote-controlled network equipment (switch, circuit-breaker),
- installing smart meters,
- deployment of grid event data collection and processing systems

Naturally, it will be easier to equip the grid as it is being constructed rather than doing so subsequently. When major renovation or conversion operations are embarked on, in particular burying the grid, it is wise to foresee intelligent equipping of it, even if the functionalities such equipment can perform are brought into service progressively:

- installing motorized disconnecting equipment (or at least equipment that can be motorized)
- fitting sensors on the grid
- fitting telecommunications equipment (in particular in trenches common with the network)

One important point will be whether or not to install smart meters. Smart grids without smart meters will offer reduced yet significant functionalities, primarily geared towards optimized grid management (identified services 1, 2, 3 and 4). Smart meters will in addition offer the functionalities of services 5 and 6.

The functions offered by these smart grids will include:

- better knowledge of loads and energy flows, thanks to available measurements, enabling optimized operation and development of the grid (thereby avoiding overloads detrimental to the life span of underground cables in particular, but also operation closer to the limits, so more efficient),

- more stable voltage thanks to better modelling of grid behaviour, to optimize adjustments,
- better integration into the grid of consumption loads (conventional and new) and generation (more particularly generation from renewable sources), through real-time flow control,
- automated operation during incidents to reduce downtime, limiting voltage surges when faults occur (which particularly age underground cables) and giving a better quality of service,
- supervision of grids giving an accurate image of their stress level and degree of ageing, thereby facilitating the elaboration of optimized renewal plans (this function is particularly interesting for underground networks that can be supervised visually, among other things with off-line and now on-line monitoring methods).

The entire asset management approach is thus modernized and enhanced.

If a network developed as a smart grid includes deployment of smart meters, new functions will be accessible:

- better management of customer contracts (remote connection and disconnection), remote meter reading,
- taking more advantage of the services of an open market: making it easier to change supplier, more accurate flow balancing (improved load profiling, more precise flow balance)
- possible involvement of customers in managing their demand by benefiting form detailed pricing signals (real-time or multiple rates), which could include home automation services.
- Better customer service by using the meter's technical data: detecting voltage shortages at the customer's, voltage anomalies and help in managing the grid
- Reduction in non-technical losses on the grid thanks to information provided by working out local energy balances.

RISK AND OPPORTUNITIES

Regarding the impact of such a project, risk and opportunities have to be examined carefully.

- Cost-effectiveness of smart grids is usually determined by a triple gain
  - gains on clientele management
  - gains on service sales and the benefits in terms of power and energy profiles
  - gains on network management

  Loss of one of these gain factors can jeopardise the business model.

- We must check the acceptability by customers, for all services needing a direct involvement of customers.

  The gains anticipated from demand management can be attained only if:
  - the customers are motivated,
  - consumption is high enough for arbitration decisions to be made,

  Yield management of demand only makes sense if the generation/consumption balance is generally achieved without frequent load shedding, and the process raises the question of personal privacy.

- The financial costs must be correctly distributed among the actors. The smart grids infrastructure is deployed mainly by network operators. The beneficiaries and service providers are the network operators, the producers and the suppliers. In an open market, how can the financial costs of the infrastructure be passed through to the service providers? How can actors be remunerated to encourage greater quality and optimise energy use? New types of regulation have to be devised.

- A substantial share of the gains stems from the automation of certain processes. This assumes reliable equipment, not requiring excessive maintenance, in the automation process. This point must be checked after time and with some experience. Any generic fault (on meters in particular) would have serious consequences.

- One of the technical challenges is the cohabitation of electro-technical systems with a working life of 30 to 40 years alongside electronic and I.T. equipment with a working life of 5 to 10 years. The shorter working life of the latter must be considered in profitability analyses.
- The ITSystem connected to the smart grids is not the essential cost factor but can be a risk factor: complexity, size, quantity of data, cybersecurity (connection between technical and commercial data). Data processing is useful only if the results are exploited and the cost of exploiting the data is high!

However, these risks must not hide the real opportunities offered by smart grids:

- The technologies are mature,
- The entrepreneurs are motivated,
- Experiments are underway in many countries,
- The political decision-makers are keeping a close-eye on smart grids as they contribute to achieving the objectives of energy policies,
- Major investment is required on a number of electricity networks, which makes it a good time to rethink their design.

CONCLUSION

Smart grids are the core element in the process to improve the quality and efficiency of service. That project federates in a world where business disciplines are compartmented. Economic, industrial and societal risks have to be managed, but it is a powerfully mobilising factor for decision-makers in recent years, as this project contributes to achieving the objectives set out in energy policies.

The expected benefits of smart grids will be all the easier to achieve as the equipment is deployed comprehensively over an entire area, even a small one. That is why burying operations are very interesting opportunities for conducting full-scale experiments. They will enable one to gradually discover all accessible services thanks to these facilities and thus to achieve a new level of performance for distribution networks.

REFERENCES

[1] European Union - TF for smart grids - WG1 final report – January 2011