PREPARE YOUR "SMART GRID" IMPLEMENTATION STRATEGY

KEY FACTORS AND TOOLS

Robert Denamur
ESRI BeLux s.a., Belgium
robert.denamur@esribelux.com

Peter Vranckx
P.B.E cvba – Belgium
peter.vranckx@pbe.be

ABSTRACT

This paper describes the steps to be taken by the DNO to prepare and follow-up the implementation of the first smart grid components; the smart meters. What tools should be taken into consideration, the practical steps to start such an implementation project and the implications for the IT infrastructure of the DNO.

INTRODUCTION

With a lot of publicity made around the “Smart Grid” a huge number of small to medium size distribution operators, some of them using very efficiently their limited resources and assets are now faced with a new challenge. Although numerous publications are available on the subject they still have difficulties in the perception of what the “Smart Grid” technology really is and what it means for them in the years to come let alone what strategy to adopt to grow through their distribution networks the nervous system like “Smart Grid” technology. Most of them understand that this new technology will make its entrance sooner or later in their network. What kind of preparations should be made attain a smooth roll out this technology? How do they measure their preparedness? How will they follow of the roll-out of this technology in their network?

Developing the right strategy and implementing this new technology is greatly facilitated with the right tools. They will assist and help the DNO, when correctly used, to assess the initial situation of their network, and especially the already available communication infrastructure, and start drafting and evaluating their implementation strategy. This is why the DNO operator GIS/Network Information system plays an important role in any serious development or implementation strategy. This will increase the need for an accurate and well managed documentation system. The paper will describe in more details the place and key role of the GIS/Network Information system in the execution of the implementation strategy, the initial data quality requirements and possible adaptations to the data structure to enable the geographic visualization of the indicators and implementation progress, as a support to the execution, and regulatory reporting of the “Smart Grid” roll-out.

In the last years there has been a lot of interest for the “Smart Grid” technologies and the revolution in the business and operations of distribution network operators this will bring about. As the first implementations have started across Europe, with the smart meter implementation, we are now nearing massive adoption within the distribution operator’s community. The Electricity Directive of the European Union foresees indeed full deployment of smart metering by 2022 at the latest. The preparations and steps described here under are part of the preparation underway at the PBE in Belgium to implement their smart meter pilot project.

Smart Grid?

What is a Smart Grid? A Smart Grid consists of a broadband communication system that uses a set of sensors and distributed computing. Thanks to the ‘Smart Grid’, the DNO (Distribution Network Operator) will turn into a reliable, self healing, fully controllable and asset efficient electrical system. [1]

This definition does not specify what kind of technology should be used to implement the communication system. A fast bi-directional communication system is the key to the implementation of the Smart Grid. Among the different alternatives, power line communication, RF – WiMax , and wired network technologies are most favored by European distribution operators, all of them using industry standard IP protocols, to enable fail-safe communication to the outer ends of the distribution network.

Actual situation of utilities envisioning the implementation of the Smart Grid

Utilities of various sizes are envisioning or will in the near future need to implement the new communication infrastructure necessary for a smart grid implementation and the first intelligent meters as their entry step to make their networks smarter.

Enterprise IT infrastructure

Their initial core IT infrastructure can vary vastly for very basic systems to already elaborated enterprise implementations.

The smallest operators, may have various networked small systems to manage their operations, like:
- Accounting software: Asset Register (management, value, amortization) and services – Cost of works
- Logistics software: Stocks (valuation, availability), Articles & Assemblies
- CRM (Customer relationship management), Customer identification, status, and quotes/pricing
- Work order system: Ordering materials, services, etc.
- Metering system (for quarter hourly values of important cabinets and customers) with ebIX/UMIX data exchange interface (for business data exchange between energy producers, energy (re)sellers, TNO’s, equilibrium responsible)
- CAD system (for design and mapping of their
Bigger operators, have usually some kind of enterprise information system, with advanced possibilities. These operators have in their enterprise IT landscape;
- a main stream integrated ERP system,
- SCADA and outage management systems (OMS) or
- Distribution Management system (DMS),
- Geographic Information system (GIS),
- Network calculation packages,
- Ripple Control system,
and other interfaces e.a. to the KLIP system in the Flemish region of Belgium.

GIS system power grid and communication links management were traditionally seen as two separated disciplines, so some operators have dedicated GIS platforms for their telco system and another for the electric system, other have separated features and tools on the same platform. Others do not have any GIS system yet.

**Communication links**
For the normal needs of the DNO’s most do use dedicated communication lines, like telephone lines, fiber optic links, but also radio frequency links. The communication to remote devices runs very often also on the electric cables, e.a. for ripple control (for tariff change, street lighting switching). The ripple control frequencies do reach the end points of the distribution network, but the ripple control does lack a return path.

**Electric assets**
In Distribution networks, unless in important cabins or transformer stations, most switching equipment and transformer tap changers do not have remote control, or signalling capability. Quarter hourly values from remote metering do provide some additional information. But in most of the cabins switching, transformer tap position are changed manually.

**Metering equipment**
In most distribution networks there is already remote metering for industrial clients, some generators and for border stations between the DNO and TNO. For household service connections, a vast number of electromechanical and some electronic meters are in use. Registration of the metering values is in this last case done manually, very often by the customer himself. As one might imagine the implementation of the Smart Grid will impact most of the systems mentioned here above.

**Steps to implement the Smart Grid**

**1. Assess the initial situation**
A sound assessment of the initial situation of the electric, telecommunication, IT infrastructure and software packages directly used to perform their tasks as distribution network operator, needs to be done before embarking in a implementation project of smart grid equipment. Most implementation projects start with the installation of new smart meters or AMI , which automatically also implies also an assessment of the existing telecommunication links available and used to control the electric network assets.

**2. Improve the quality of asset registration**
To have a representative view of the electric network and communication links available high quality and reliable network information data needs to be available. The best way to do it is to use a modern GIS system, with detailed inside plant registration capability for this purpose. Even if it is the case you will need to implement quality measures and a validation workflow to make sure the data recorded is consistent, e.a. nominal voltage and phase identification are consistent from section to section. As networks do change due regularly due to various incidents, replacements, urgent extension projects, it won’t be a surprise to find unrecorded, erroneously or non recorded elements at different locations in the networks.

Various client loads, or load profiles, and various distributed generators, PV cells, wind turbines, appeared recently on each certain branches of the distribution network, and might be missing in the GIS system.

It is therefore also of importance to verify the data in the field and correct/update the data of your GIS system accordingly. A modern GIS system will not only provide the localization and mapping of small generators, your network assets, especially of the electrical circuits, communication links and nodes, but will also provide to you connectivity validation, QA/QC and work-flow tools. Specific GIS presentation layers should be used to monitor the overall progress of the data gathering and validation processes, and e.a. the quality indicators per area.

**3. Adapt your GIS data schemas**
In the Flemish region of Belgium, a group of distribution network operators, Eandis, PBE and Infrax decided to prefer and implement PLC communication on power lines to reach the new smart meters and end points of the network. This last kilometer communication will use CENELEC – A band [2] with a frequency range between 45 kHz and 90 kHz, well above the ripple control frequency range of 110 Hz –1600 Hz, already injected on these power cables. Power line carrier signals on the cables will be used with the possibility to use a secondary or back-up communication link, such as alternate internet connection points, to avoid communication disruption for single failures.

Other distribution network operators in Belgium do
envision the bi-directional communication links from transformer cabins up to the meters using RF-WiMax antennas. To cover and document those communication channels superimposed on the power cables change in data schema of most GIS systems would be required. New objects need to be foreseen in the data model, e.g. new coupler nodes or RF nodes, the data schema needs to be adapted to support multiple communication channels on the electric network.

In the past few GIS applications did support an integrated communication and electric network data model. Most suppliers of GIS solution suppliers would even propose separate solutions for the communication infrastructure and a separate solution for the electric network infrastructure. This was not really a problem with legacy telemetry and telecontrol applications using low speed modems using, most of the time dedicated wired links, telephone cables or fiber optic cables. But with the advent of the smart grid, this requires a second analysis. The preferred way, at the PBE, is to have one integrated data model for electric power distribution and telecommunication. It is also necessary to prepare the data structure for the follow-up of the implementation of smart meters and other new smart devices.

4. Implement new tools and enhanced tracing
Check Tools and communication network trace selection tools need to be able to run across the communication links but also on the power lines. Also when running communication traces, with RF links for the final part, the resulting selection of objects should also be able to return the smart meters within e.g. the WiMax antennas coverage.

5. Implement new interfaces around the GIS system
New interfaces between the GIS system and the smart metering system will need to be implemented, especially to geographically locate outages, as the smart metering system will be able to provide this information much faster than the outage complaints from customers. Also restoration times and outage impact indices will be more precisely recorded to be associated with a cause or reason description. Localization of mobile consumers at their (re)loading/consumption point on the distribution grid will be also be available.

A more precise power consumption- or production profile can also be made available to the GIS system through the interface to the new smart metering system. This will also allow for more accurate dimensioning calculations with grid calculation software. The new communication nodes and communication links will also be monitored by a communication supervisor platform. This supervision system can also be interfaced with the GIS system to localize important anomalies, faults and breakdowns in the communication links.

To further shorten service restoration times, crew or service vehicle GPS localization should also be interfaced with the GIS system. On the other hand, service crews will have an up to date view of the electro-telco network and fault location will be available on their ruggedized laptops. Usually this GIS interface to one of the many possible external electric grid calculation software tools. It might be useful to verify if upgrade packages of these modules now include distributed generation, as photovoltaic panels, wind turbines production, and other water turbines, and allow for calculations in different meteorological conditions and time of the day. Besides the calculation of the attenuation on the dedicated telecommunication links, the communication links calculation and dimensioning tool, should also receive the low frequency transmission characteristics of the electric objects included in the transmission path. This information can be extracted from the GIS system, based on a selection trace to enable the assessment and the reach of a signal injection point, and evaluate the need for repeaters, amplifiers or other high transmission capacity links.

With the GIS system and the adapted telecommunication system dimensioning tools it will be possible to estimate the consequences of the implementation of the new smart meters on the data traffic, on the whole, and per segment of the electro-telco network.

6. Upgrade/replace other IT systems
The treatment of the data stream coming from the smart meters will also generate new functional and performance needs especially for the metering system. New high performance metering servers and data concentrators located at key points of the network will be needed to handle the data generated and to translate this data for the other IT systems of the distribution network operator. The installation of a new telecommunication network supervisory system might also be needed to monitor and remotely manage the communication equipments.

7. Upgrade/replace electrical assets and equipments
The further steps along the path will be the implementation of remote control at every level of the electric distribution network, which will require the replacement or upgrade of electrical assets. Which much better observability of the distribution network and improved controllability the new distribution network will be far smarter than ever before, and will have the capability to resolve automatically some of the events to
which the network might be subjected.

**CONCLUSIONS**

The preparation of the implementation of the first elements of the smart grid, like the new smart meters, and the necessary changes to the communication infrastructure will benefit from a strategy incorporating the use of a modern GIS system, with some functional improvements and adaptations to the data model and tools.

The upgraded GIS system, with a centralized, multi-disciplinary database, will allow you to choose the areas where it will be easier and/or economical to start the implementation of the new metering infrastructure, allow for a faster roll-out and deployment follow-up and internal and external reporting.

It will also make the communication with the clients more efficient, through targeted mailings to the groups of clients by the meter replacement impacted clients.

Implementing fully the “Smart Grid” for a distribution network operator will require supplementary investments a.o. to implement automation in the MV/LV networks to enable self-healing capabilities, of many orders of magnitude greater than what a new or upgraded GIS solution will cost. This last investment will pay itself back due to a.o. the sound prioritization of the investments, and efficiency improvements, made possible with the help of the GIS system.

**REFERENCES**
