SOUTH EAST EUROPE STYLE SMART METERING: THE COST EFFECTIVE SOLUTION FOR AN AGEING NETWORK

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ABSTRACT

Among the utilities of the South-East Europe Area, EPCG will be the first to deploy a fully operated smart metering system, covering more than 80% of its Customers in a few years.

The deployment of a smart metering project may ensure several benefits for the Distribution Utility, for the Customers and for the whole Electrical Power System.

DSO will improve economic and financial performance by reduction of losses, optimization of field operations and improvement / stabilization of credit collection.

Consumers will have better services with quicker contract activation, deactivation and modification; thus, their relationship with the DSO will be improved by the diffused availability of information on outages, quality of supply and consumptions. Moreover, detailed information coming from the smart metering will enhance Consumers' awareness about energy utilization, thus contributing to optimization of energy consumption and economic benefits.

A smart metering deployment, once chosen a reliable, "field proven" technology, also involves a strong logistic activity, requiring a jointly coordinated action of the several stakeholders involved within. Finally the head-end system and the meters should be designed to deliver a fine tuned set of functionalities. All these actions, solutions and functionalities are implemented to reach given profitability targets and facing existing problems such as technical and non-technical losses.

EPCG, with the contribution of all the involved Suppliers, has been designing and setting up a sustainable and standardized smart metering solution, in order to achieve not only the aforementioned traditional benefits, but also concrete answers to the Montenegrin grid specific needs, arising from ageing and low performance.

INTRODUCTION

The Montenegrin power sector is representative of many West Balkan energy sectors: it is characterised by several decades of under-investment, a capacity deficit and high levels of energy inefficiency and carbon intensity. Generation is dominated by hydropower and lignite fired thermal capacity, but the country is heavily dependent on imports to meet total consumption. Energy intensity and carbon intensity are 73% and 100% higher respectively than OECD averages.

The largest company in the sector is Elektroprivreda Crne Gore AD Nikšić (EPCG) which is, in practice, the sole electricity generation, distribution and Supply Company in Montenegro. EPCG is distributing electricity to over 600.000 people through 360.000 meters.

One of the major challenges facing EPCG and its shareholders is addressing the high level of losses and bad debts in the distribution network. Losses were 23% in 2009 compared to best international practice of 6-8%, while the collection rate was less than 90%, compared to best international practice of over 99%. In addition to contributing to Montenegro's high energy intensity this issue is an obstacle to the on-going development of the Company, reducing its cash flow and so constraining its ability to carry out necessary investments, particularly in its ageing generation assets. Recognising the importance of this issue, and the role of metering in addressing it, one of the targets set for EPCG in 2011 has been the installation of at least 175,000 smart meters within four years.

The EBRD Bank proposed a loan to address the challenge by funding the acquisition and installation of these 175,000 meters throughout the Montenegrin distribution network, together with the related software, systems integration and ancillary facilities.

These particular needs of EPCG required:

- a specifically designed "Company standardized" set of solutions for installation;
- the design of a set of functionalities for the metering system, allowing a safe and secure remote management of supply and providing information about Quality of Service and Load Flow, laying the foundation stones for smart grids;
- a robust and reliable field solution providing the designed functionality, already proven on high volumes;
- a flexible and fully automated system.

SYSTEM ARCHITECTURE

Through the tendering process, EPCG selected field and system solutions that have been demonstrating in the past years to be robust and reliable in large scale implementations [1].

The main components of the resultant automated metering infrastructure are:

- the head-end system to remotely manage the billing information, monitor the quality of service and provide support to the roll-out;
- the low voltage concentrators (LV-C), installed in the secondary substations, to aggregate data recorded by the meters;
- the meters to remotely read the consumptions and manage the customers' supply contracts.

The head-end system selected is called AEM2and provided by ATOS/E-Utile, while the field devices selected are part of ENEL solution.

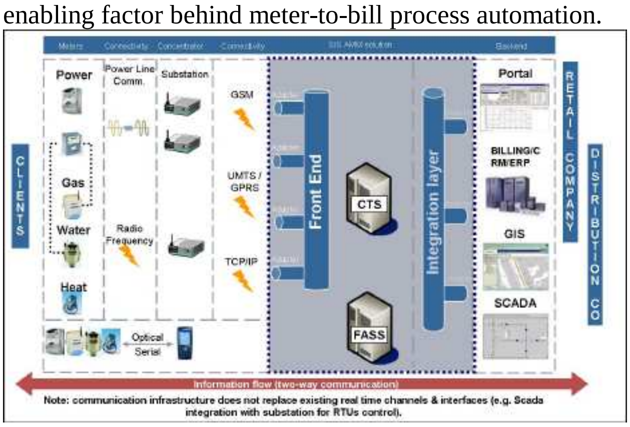
Head-end system

A high-level description of the AEM2 solution, both from a functional and a technical perspective is currently described in order to provide its main capabilities and the most relevant technical aspects.

The following figure provides a view of the AEM2 architecture, which is made up of the following components:

- the Dominio Centrale (DC), which is, in turn, composed of the Front End (FE) and the Centro Tele Servizi (CTS) modules;
- the Field Activity Support System (FASS).

The picture also shows how the AEM2 solution is able to integrate with all the elements that compose the smart metering landscape: this end-to-end integration is the key enabling factor behind meter-to-bill process automation.

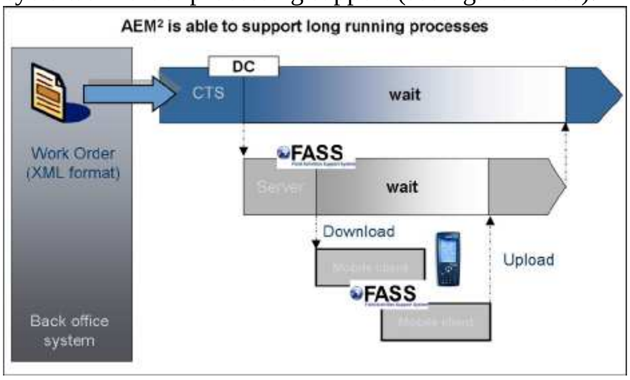


A view of the head-end architecture

By means of the AEM2 solution, electronic meters are remotely managed over a bidirectional communication channel: to the remote control center the meters appear as terminal points on the grid, to which information and/or commands can be sent (e.g. tariff plan information, power variation signals, etc.) and from which data can be read.

In EPCG project the Data Concentrators are part of the field infrastructure, allowing the control center to manage multiple meters in parallel, as a group.

Meter data is collected via adapters by the DC, validated, estimated (if required) and then stored in the system's central repository (a relational database). A process engine (located in the CTS module) and extensive integration capabilities ensure end-to-end functional integration with back-end legacy systems: work orders, typically originated in the back-end-systems, are automatically updated by the AEM2 solution at the end of the process lifecycle (no human intervention is required). Processes that require field activities are managed by FASS. There is full process integration between the DC and FASS, ensuring full life-cycle work order processing support (see figure below).



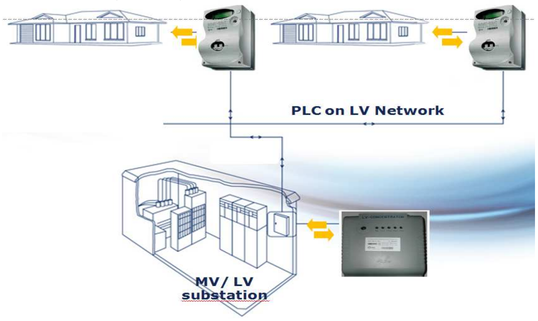
Full process integration between the DC and FASS

The main functionalities of the FE are two: Field Communication and Alarms Management.

Finally the CTS is the AEM2 solution module where the metering business logic is implemented. It is designed as a service-oriented application able to manage specific metering processes, such as connections, disconnections, move-ins, etc. These processes are exposed as services for external systems to consume (e.g. billing, CRM, GIS, etc.) or can be manually initiated by means of the CTS web administration console.

Field Devices

The AMI field devices by ENEL are the low voltage concentrators (LV-C) and the smart meters.



A view of the field architecture

The LV-C is a key element of the overall system architecture, able to manage communications in two directions, towards the smart meters via powerline in Cenelec Band A, according to EN50065-1, and towards the head-end system via public GPRS communication network, not only acting as a mere aggregator of information and/or gateway for communication purposes.

Remarkably, the LV-C operates as an intelligent device allowing local metering operation and the optimization of

the costs of communication with head-end system.
In particular the list below shows the key functionalities that are considered useful for every soundly built project but specifically required for EPCG project:

- gathering and transmission of power consumption, load profile, useful for load balancing [2];
- alarm driven behaviour to report critical events, useful to support fraud contrast activities;
- increased reliability of the powerline communication, since each meter can act as a repeater for the others.

Finally the smart meters installed in Montenegro present all the features required from an environment characterized by the need of fraud detection and energy balance functionalities, such as:

- measures of energy in all quadrants both for active and reactive powerin programmable time intervals;
- measures of RMS values of current and voltage;
- availability of flexible multi-tariff;
- load profiles with programmable duration;
- updating of firmware by remote;
- disconnection of the main supply;
- voltage quality and outages recording;
- communication interfaces protected by means of authentication algorithms.

PRE-INSPECTIONS, INSTALLATION AND COMMISIONING

EPCG, in the tendering phase for installation, defined a standardization of works, both electrical and civil, to be performed in order to have the new smart meters properly installed. The scope of these works is assessed by pre-inspections on-field. A team of inspectors by EPCG and MEZON, the fitter company, agrees the set of works.
A special software tool has been developed by EPCG, based on indications of ATOS/E-Utile, for the following tasks:

1. extraction of data from billing system;
2. recording of works to be done;
3. generation of work orders, to be then managed with FASS (Field Activity Support System).

The tools is called “integration module” being the “trait d’union” between the legacy billing system and the AMM software.
The Field Activity Support System (FASS) by ATOS/E-Utile, instead, is a workforce management solution specifically designed to complement AMM and MDM systems, by providing functionalities and automation support for on-site meter operations. There are two main components to the solution:

- the FASS server, i.e the central processing system that provides work order management functionalities (planning, scheduling, dispatching, etc.) and reporting tools;
- the FASS client, i.e. a client application (commonly installed on a PDA) that can be thought of as an “electronic screwdriver” that provides field staff with a direct interface to the smart meter devices.

One of the main values that the FASS solution is able to deliver to grid operators is the possibility to monitor and control the massive meter replacement process on a daily basis (or even in near-real time, should this be required), even if this activity is contracted to many external teams.
This is possible because once the orders are downloaded to the mobile devices, they are executed by the field staff and then sent directly back to the distribution company’s FASS server via GPRS Communication, if required the real time, otherwise once a day when the fitter goes back to the office. In this way, the order status is updated and all the additional information sent by the field device is recorded on the central server in near-real-time.
By means of the FASS management console, it is possible to define Key Performance Indicators and measure the work progress of each subcontractor based on those indicators.

Most of time, massive roll-out involves also several local physical activities to be performed. Taking the opportunity of meter changing, indeed, the utility normally decide to perform other activities as meter moving, cabinet renewing, etc. This is the case of EPCG where the massive roll-out includes a lot of different works that the fitter performs, caused on the local conditions of the meters or on the local LV grid situation. EPCG together with the consultant CESI defined a standard way to approach any possible variation that could be matched by the teams, designing more than 40 different standard cases. Each of them is described not only in terms of activities, but also with a standard time to be executed and standard cost.
Once a lot of substitution is created, an inspection visit is managed by EPCG together with the installation company for the big buildings where a lot of meters has to be replaced. During this phase the composition of the global work to complete the building is shared among the parties. The “solution” is managed by the FASS and related consistent work orders are created and managed according the standard flow. The work order is completed only when all the meters in the building are replaced.
Using a reliable software solution able to map the complexity of the activities, EPCG is able to sustain an aggressive meter roll-out plan.

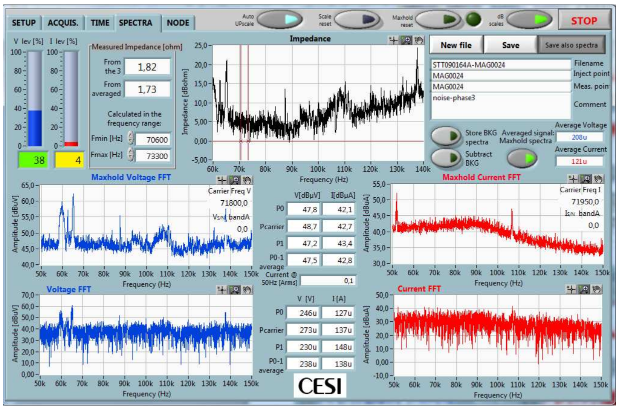
POWERLINE COOMUNICATION ANALYSIS

The assessment of powerline communication supports the commissioning and reading rate improvement. Once all the components of the AMI system prove to be perfectly working, the causes of the problems have to be searched in the “communication media”, that is the electrical network itself. The following measurements have to be carried on, in typical sites, in the range from few kHz to 95 kHz (Cenelec Band A):

1. measure of the background noise

2. measure of the level of signal
3. measure of attenuation between two points
4. measure of the Impedance in band of interest

A specific powerline instrument, developed by CESI, can display and store the data both in time and frequency domains.



Screen shot of CESI instrument for powerline analysis

Measure of the background noise

This measurement requires that no PLC traffic is present on the low voltage network (230Vac). In order to have fake measurements, it is necessary that all known PLC traffic will be stopped, so that no messages could originate from the LV-C and, as a reply, by the meters. The measures must be taken at the position where the LV-C is likely to be installed and along some points where the smart meters shall be installed, at different distances from the source of PLC signal or from the possible source of noise.

Measure of the level of signal

This measurement requires that a signal is injected on the LV network in a defined and known point. The signal can be injected using a generator. During the assessment, a particular device, capable of generating PLC signal sweeping from few kHz to 95 kHz is used. According to the different measurements, the generator can be installed in the sub-station, where the transformer is located, thus simulating the LV-C, or near the installation point of one Meter, thus simulating the traffic generated by a smart meter in response to the LV-C call or when it acts as a repeater to query information to another meter.

Measure of attenuation

The measurement of the signal level, taken in two different points, gives the indication of the overall attenuation of the signal, due to many factors such as loads (causing both noise and low impedance), junctions and line.

Measurement of impedance

In order to estimate the impedance in different points of the net, the following approach has to be followed:

1. the Generator must be connected in the point of measurement, with frequency sweep in the range of interest;
2. a voltage probe must be connected in the point of measure;
3. a current probe must be connected on the line in the point of measure;
4. voltage and current spectra are acquired;
5. starting from the measurements obtained at point 4 an estimation of impedance must be calculated.

After the collection and the analysis of specific measurement campaigns, in Montenegrin installation it has been possible to design new solutions where some LV-Cs have been located outside the secondary substations, where the powerline communication is working better or, in other cases, some repeaters (i.e. meters without real customers) have been added in specific locations of the sub-networks in order to increase the reachability of the meters and bypass the problems caused by the communication media.

CONCLUSION

The solutions have been tailored on Montenegrin needs, very common in the Balkans area. Specific features have been adopted regarding reduction of losses, optimization of field operations and stabilization of credit collection.

As regards the reduction of losses, in EPCG project this area of improvement is strictly connected to the implementation of fraud detection and energy balance functionalities through tamper alerts, improved meter protection, load profiling and MV/LV substation load balance.

For what concern the optimization of the field operations, it surely starts from the reduction of low value activities like readings, activation, deactivation, bad-payers management, voltage monitoring and outage detection. Workers can thus be trained to increase their skills in order to perform core activities like predictive maintenance, network improvement and development.

Finally the operating cash flow in a DSO is influenced by the payment regularity of the invoices. Missing or delayed payments cause financial shortage and increased cost of capital.

After the first year of massive deployment, more than 70.000 meters are in operation and first measures of the project KPIs indicate that results are very encouraging:

- average losses reduction of 30%,
- percentage of successful bill collection increased from 24.4% in previous year to current 75.5%,
- first step towards smart grid deployment.

REFERENCES

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