TRANSITION TO SMARTGRIDS IN DEVELOPING COUNTRIES, CONTRIBUTIONS FROM TELCO OPERATOR IN TELECONTROL OF ELECTRICITY DISTRIBUTION NETWORKS: SENEGAL CASE STUDY.

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ABSTRACT

Electricity is vital and essential in the life of modern societies. Delivering electricity with high level of quality and availability becomes a priority challenge. Telecommunication availability is one of the most significant key factors for success in implementing a modern and smart distribution system.

The development of telecommunications with mobile phones have been changing the lives in developing countries more than any other invention before. Mobile phones provide a wide variety of services with some new needs and usages specific to emerging countries like mobile money.

Thus, operators' telecommunications networks have an important role to play in the efficient management of electricity networks and the transition towards smart grid, particularly for developing countries.

As a vivid illustration this paper discusses the case study of the distribution automation of Senegalese power grid with GPRS / 3G conducted during the year 2018.

INTRODUCTION

Electricity is vital and essential in the life of modern societies. Delivering electricity with high level of quality and availability becomes a priority challenge.

As the last step in the customer's power delivery process, the electrical distribution network suffers from numerous outages. According to the technical literature [4], approximately 80% of customer service interruptions occur due to problems in the distribution system process

Distribution Automation (DA) is for sure the key factor for efficient management of the power distribution networks since it contributes to mitigate the impact of power outages with the reduction of fault location times. In fact, when the automation of a distribution network is rudimentary, incident operations are often long and complex. Simple failures, due to lack of information, can be complex to process.

However, distribution automation is conditioned on the availability of a reliable telecommunications network.

Traditionally, electricity companies have built independent and autonomous telecommunications networks to ensure the remote operations of their facilities. Nevertheless, this network is characterized by its high operating costs and has become obsolete over time.

In addition, in recent years there has been a rapid development of telecommunications networks operators' providing various services.

In response to the power distribution operational problems in developing countries, telecommunications networks have a fundamental role to play in the efficient management of power grids.

This paper provides the case study of the implementation of telecontrol of Senegal's distribution network from the GPRS/3G network of telecom operators conducted in 2018, which impacted significantly on the operation of the electricity grid.

In the rest of the paper we discuss successively: telco network impact in developing countries, challenges in the operation of power grids in developing countries, power distribution automation and Senegal case study with impact of the project and lessons learned.

TELCO NETWORK IMPACT IN DEVELOPING COUNTRIES

The development of telecommunications with mobile phones have been changing the lives in developing countries more than any other invention before. Mobile phones provide a wide variety of services with some new needs and usages specific to emerging countries like mobile money.

This development generally leads to the rapid expansion of infrastructures making this medium become an undeniable pillar for digital transformation in all sectors of activity.

Thus, operators' telecommunications networks have an important role to play in the efficient management of electricity networks, particularly for developing countries.

In developing countries cellular network can actually be much more advanced than energy infrastructures. For instance, taking Senegal as a typical case of a developing country, during the last decade its mobile phone usage has increased dramatically from 1.7 million subscribers in 2005 to 13.1 million in 2013, thus covering about 95% of the country's 14 million inhabitants [1].

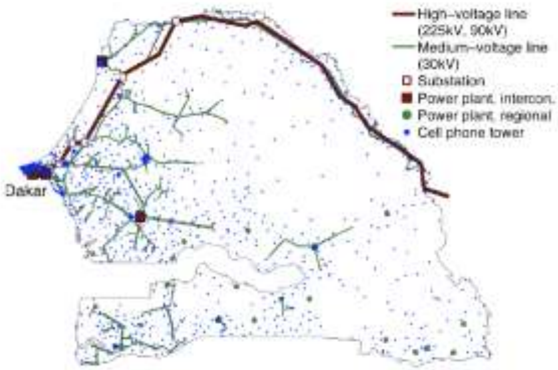

Fig. 1. Existing electricity infrastructure in Senegal and location of the mobile phone towers 2013 [1]

The geographic location of the mobile phone towers is depicted in Fig. 1, which also shows the topology of the electricity transmission and distribution networks.

CHALLENGES IN THE OPERATION OF POWER GRIDS IN DEVELOPING COUNTRIES

While for developed countries, lifestyle comfort is based on the permanent availability of increasing quantities of energy, for developing countries, better access to energy services is one of the vital conditions for emergence.
In contrast with developed countries where demand is accurately forecasted, adequate infrastructure investment is scheduled, and networks are well managed, in many developing countries electricity generation capacity is underfunded and/or infrastructure is poorly managed.
Consequently, power companies face disruption of electricity supply and customers undergo several hours of power outage throughout the year, a situation that can severely impact the economy and the social stability.
Further, the distribution network is generally characterized by high technical and commercial losses across the entire power system network. Whereas high technical losses are a result of inadequate investments in the network infrastructure - which resulted in unplanned extensions of the distribution lines, overloading of the transformers and conductors/cables - commercial losses is largely due to low metering efficiency, theft and pilferages which is a major concern for utilities. Deploying a system to automate the secondary network is seen as one of the ways of addressing these ills that plague the distribution sector in developing countries.

POWER DISTRIBUTION AUTOMATION

The term "distribution automation" connotes a wide set of technologies and approaches to the remote operation of distribution networks. Distribution automation can be alleged of as “a set of technologies that enable an electric utility to remotely monitor, coordinate and operate distribution components in real-time mode from remote locations.

Distribution automation principle

In a control system, so-called "intelligent" devices are responsible for collecting information and sending commands to network devices. It is generally a driving system that allows to:
- know the state of these organs;
- measure some parameters;
- control the switching devices;
- communicate information;
- report alarms for the operator.

Telecommunication solutions for power distribution automation

Telecommunication availability is one of the most significant key factors for success in implementing a modern and smart distribution system. The top levels of wireless technologies for Distribution Automation (DA) application are private infrastructure and telco network (public carrier)

Private infrastructure - Private infrastructure refers to utility-owned, closed-loop wireless networks.
Initial capital expenditure of a private infrastructure can be costly and require very often licences which are protected by regulatory agencies.
Proprietary broadband solutions have been successfully deployed for over a decade for power utilities. These solutions provide good throughput balanced with good range and acceptable latencies. Since these solutions are proprietary, the ecosystem of solutions is limited to a specific vendor for a specific implementation. Also, QoS is often implemented to a minimum level. Proprietary broadband solutions are field-proven; however, the proprietary nature locks a utility to a specific vendor.
Over time, to maintain high availability, this network requires a special follow-up with the establishment of a specialist team for operation and maintenance.

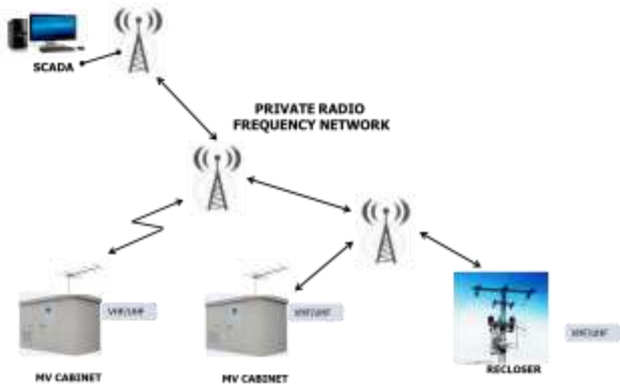

Fig. 2: private telecom infrastructure-based DA

Telco Network – Telco carrier infrastructure provides pervasive coverage in most populated areas, significant throughput, moderate security, and response times under 100 ms. However, the concern remains whether public infrastructure can facilitate guaranteed prioritized service. Many carriers are working on features to support prioritized service-usually with a higher rate of pricing. If a utility is in an area with pervasive public carrier coverage with a guaranteed level of service at a fixed price, this would alleviate the initial capital expenditure of a private infrastructure. This is often not the case. Furthermore, over several decades, public carrier performances and robustness have been validated by a vast number of end-users.
In summary, public carriers have evolved to meet many needs of power utilities and require limited capital

expenditure. They provide moderate throughput, pervasive coverage, acceptable latency, and adequate security features, but the need for additional security, channel availability during emergencies, and the ability to pass sufficient data in the uplink remain areas of concern [3].

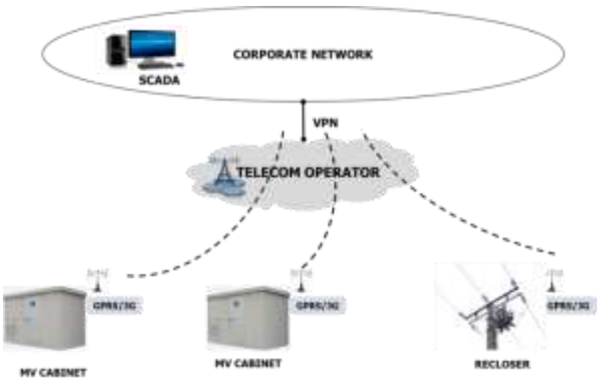

Fig. 3: Telco Network based DA principle.

Figure 4 depicts a high-level guideline to the benefits and deficiencies of each technology inspired from [3].

	Public Carrier	Proprietary Broadband
Throughput	80	80
Range	80	60
Latency	80	70
Security	40	90
QoS (Prioritizaton)	35	90
Uplink Biasing	30	70
Ecosystem	90	20
First investissement	80	30
Time to deploy	90	30
Operations Cost	45	90
FINAL SCORE	650	630

Fig. 4: comparison of the two main wireless options for power utilities

As illustrated in figure 4, from an economics and speed of deployment point of view, using an existing communications network instead of deploying an entirely new infrastructure is more efficient and can conduct to quick wins. In this way, utility can save money and plan to invest in private infrastructure.

SENELEC CASE STUDY

Senelec (Senegalese National Electricity Company) has nearly 1.5 million customers. The distribution network includes about 12,000 km of 30 kV and 6.6kV cables and lines connecting 6,500 distribution substations [4].
Up to then Senelec was struggling to emerge telecontrol of its distribution network which was confined to its classic VHF network that become obsolete and having shown its limits especially in urban areas due to the dense and anarchic urban development experienced in many African cities.
The current system is based on a SCADA acquired in 1999 in replacement of the first one installed in 1985 which had limits vis-a-vis the functionalities that emerged around the 2000s (the bug of the year 2000). The successive upgrades in 2007 and 2012 did not achieve the desired objectives mainly because of the limitations imposed by the old radio communication infrastructure.

Pilot project

Several distribution automation projects have failed until June 2017, when Senelec was able to test the first RTU remotely controlled by GPRS.
The expansion of this solution was immediately launched with the installation of a hundred of RTU controlled from mini-Scada via GPRS/3G allowing to obtain following results in June 2018:

- On 20 feeders with at least 3 remote control points, Senelec succeed to restore from 80% to 90% of customers between 1 and 3 minutes when permanent fault occur.
- On 30 feeders with one or two remote control points, Senelec succeed to restore from 30% to 50% of customers between 1 and 3 minutes when permanent fault occur.

In short, with this installation Senelec was able to reverse the trend by transforming its outage duration measurement unit from hours of cuts to minutes of cuts and thus reducing Energy Non-Supply Index (ENSI) by more than 70% on these feeders.

Widespread use of the solution:

With the success of pilot project, Senelec continue widespread use of the solution. By the end of 2018, every feeder has almost one remote controllable point. As a benefit:
- Subsequent reduction of ENSI by more than 56% between 2017 and 2018
- Customer restoration time is less than 5 minutes from more than 90% of customers
- SAIDI reduced by more - 80.7% between 2017 and 2018

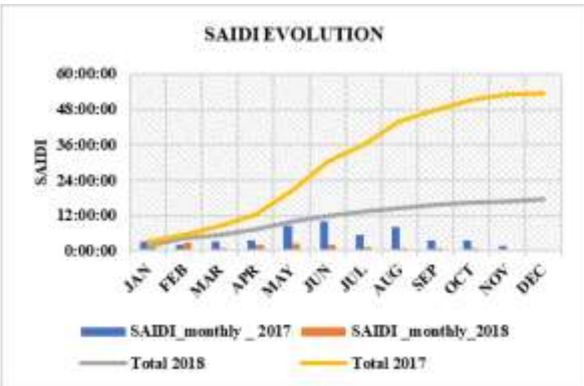

Fig. 5: SAIDI evolution between 2017 and 2018

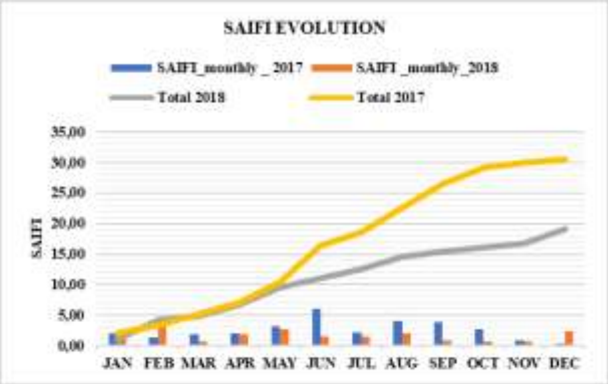

Fig. 6: SAIFI evolution between 2017 and 2018

This alternative, offered by the GPRS/3G modules, makes it possible to serenely finalize the prerequisites for implementing a reliable radio network through the ongoing deployment of a TETRA Radiocommunication System satisfying both the objectives of the operation and the objectives of telecontrol and commissioning of Integrated Distribution Management System (IDMS) expected in early 2019 which will grant advanced functions:
- the self-healing of the distribution network (detection, location, isolation and automatic recovery of customers in a few seconds following a fault without the intervention of the BCC operator)
- automatic detection of low voltage failures without waiting for customers trouble call from call center.
- Improved monitoring of the quality of service (current and voltage) with information from smart meters
- Informing customers in a more reliable and accurate way about network outages and planned work (by email and SMS)
- Preparation for the massive introduction of renewable energy into distribution networks, particularly distributed generation.

Lessons learned:

Telecom Network Reliability measurement- deployed RTU needs to be able to monitor telecommunication reliability through Receive Sensitivity (RSSI). This measurement signal strength from different part of the country can be useful for monitoring Telco Network QoS and transferring between telco operators if necessary.

SMS based data service- deployed solution need to support SMS based operation. In fact, SMS has been arguably the most popular wireless data service for cellular networks. Due to its ubiquitous availability and universal support by cellular carriers, it is a good alternative when GPRS/3G network is not working. We found having implemented SMS based solution useful and sometimes more reliable than GPRS in rural area or when VPN service is down.

RTU Design- the DA RTUs installation is also a challenging task as the space where these need to be installed is very limited and many a times these will need to be installed on pole-tops, co-housed with ring main units (RMUs) or be installed on street sides.

Solution reliability- all decisive parts of the network need to be duplicated, so that if e.g. one of the SCADA center does not function, the RTU device uses a backup routing function to access a second SCADA center.

CONCLUSION

In this paper we discussed how using telco network we can improve power distribution efficiency through distribution automation. The case study of the implementation of telecontrol of Senegalese distribution network from the GPRS/3G network of telecom operators conducted in 2018, which impacted significantly the performance of the electricity grid is presented.

As conclusion, the results are extremely encouraging and highlight the potential of telco infrastructure to support quick spread of smart grid in developing countries.

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