

INTELLIGENT INTEGRATION BASED ON OPTICAL TELECOMMUNICATIONS TO OPTIMIZE DISTRIBUTED GENERATION

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ABSTRACT

In recent years, COLOMBIA (like other countries) has gradually increased its energy demand while incorporating new sources of distributed generation, especially sources regarding small hydropower plants (SHP). SHPs in Colombia have a capacity of up to 25000 MW. However, including the 200 PCHs installed recently, the country only takes advantage of only 1% of this power.

Because Colombia is vulnerable to climate changes, especially changes in river flows associated with distributed generation, the great challenge to exploit SHP-based generation potentiality is to provide stable integration of SHPs with the existing electrical systems of distribution. In order to optimize power dispatch as a function of the weather conditions and power system contingencies, it is necessary to monitor and exchange critical information between the distribution network operators and the distributed generators. This exchange requires high reliability and fast response times in the communication networks between the distributed power generators and the companies (operators) running distribution systems.

The solution presented in this article, based on recent developments in Colombia, suggests that communication networks based on optical infrastructure are an effective long-term solution that proves suitable for the current challenges of such intelligent networks, such as the integration of distributed generation. These networks facilitate the operation of the whole electrical system, providing highly reliable communications and enhanced capacity as well as low latency and a good level of OPEX.

The solution presented shows the advantages of using optical communication networks for the integration of distributed generation and power operation systems in both the medium and long term. Additionally, guidelines on the implementation of such integration are provided.

INTRODUCTION

Distributed generation in Colombia, as in other developing countries has been increasing over the last decade [1]. Its integration with distribution and transmission systems is based on well known solutions such as: Satellite communication, cell operators, power

line carrier (PLC) and optical fiber.

Based on these studies, the main advantages of optical solutions were identified [2] and concluded that this investment was feasible because it ensured the long-term sustainability of distributed generation projects in Colombia.

Also it is remarkable to note that optical solutions have a high reliability which facilitates the incorporation of new technologies in monitoring and control of power systems which is a positive effect in the industry as a whole.

This experience is based on a review of the technologies that have been permanently in the transmission and distribution systems as well as the specific characteristics of the communication elements of distributed generation which must be taken into account in the operation from the control centers.

TELECOMMUNICATIONS OPTIONS RELATED TO DISTRIBUTED GENERATION PROBLEM

Distributed generation has been developed in Colombia mainly through hydraulic projects, where utilities companies responsible for urban water systems have identified opportunities for small hydropower projects adding energy efficiency concepts as well as a new source of income by selling electric energy which is directly connected to distribution networks in cities

In this scenario, the connection of distributed generation plants to the power system involves monitoring them from the control center that belongs to the distribution operators. They need to know detailed information related to the generation process in order to control voltage and make adjustments to the system contingencies [3].

This information relates to real-time variables, usually at intervals of 2 seconds for measurements and less than 1 second to load shedding schemes [4]. It is also necessary to consider trends in Colombian electricity sector where the remote equipment management is becoming more common which implies that it is not possible to know what will be the bandwidth requirements in the future.

Taking into account these considerations we identified that communication solutions between control centers and distributed generation operators need to avoid alternatives with high latency or without high availability. In addition, the solution should be designed for the long term.

TABLE 1. COMPARISON OF TRANSMISSION MEDIA
CATEGORIES: L (Low), A (Acceptable), H (High), U (Unlimited)

Medium	Latency	Bandwidth	Availability	CAPEX	OPEX
Optical fiber	L	U	H	H	L
Cell operators	A	A	A	L	L
Satellite communication systems	H	A	A	A	H
Power Line carrier (PLC)	A	A	H	A	A

According to this, table I shows some options for solving the problem of communications between control centers and distributed generation nodes.

Previously, it was identified that solutions using cellular modems face significant efforts to have a high availability because the areas where they are installed usually have large voltage changes as well as issues related to grounding systems [5]. Unlike optical fiber, for cellular communication systems it is very difficult to get equipment that meets these tolerances or being under the standards as IEC 61850-3 or others.

Satellite communications [6] were initially used as a solution in Colombia, but were replaced by optical fiber connections because they presented low availability in very difficult atmospheric conditions such as heavy rains. This was unacceptable as the conditions are those where it is most necessary to control and monitor distributed generation

Regarding solutions as PLC (Power Line Carrier), the vast majority of projects have faced issues related to equipment reliability in extreme conditions, mainly in areas with high ceramic level [7]. Thus, the failure rate of this equipment was very high with respect to the requirements of the electricity sector

Optical Solutions looks as the most feasible option. In fact, nowadays 100% of the Colombian electrical substations are using optical fiber communications.

Optical solutions

Solutions using optical fiber have been adopted in Colombia mainly due to a long-term vision about the growth of this infrastructure. This was initially developed in the energy transport systems and was then implemented in the distribution ones [8]. Because of

this the CAPEX in such projects has gradually decreased making it now possible that these initiatives are cost effective when the distance between the optical fiber network owned by the transport and distribution companies and the distributed generation source is less than 5 km.

Given that these projects usually involve the construction of electric power networks then the marginal cost of adding optical fiber cables is not significant in proportion to the total project cost mainly in medium voltage networks which are aerial [9].

For this reason, in Colombia, 85% of distributed generation in the range between 20 MW and 2 Mw is linked to the optical fiber network whose backbone goes along the electric infrastructure of transmission and distribution.

The same solution has been used in recent years in distribution networks whose communications availability and information exchange have been made in optimal conditions. Optical fiber networks enable the promotion and development of new technological improvements at the level of automation and advanced control algorithms which allow better use of the advantages of distributed generation when is connected to the electric network.

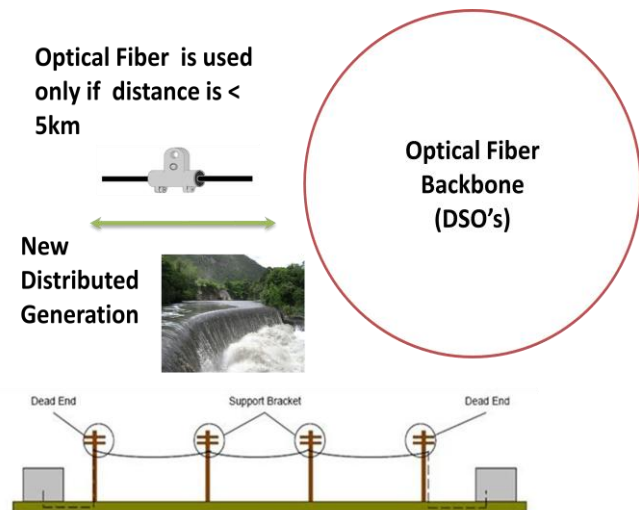


Figure 1. Current connection of distributed generation to the existing optical fiber network

Given the wide coverage of the optical fiber infrastructure within the network of transmission and distribution of electric energy, the following standard has been applied to the electric industry in Colombia: All sources of distributed generation are added to the

optical fiber backbone if they are located within a distance of 5 km as it is shown in figure 1.

CONCLUSIONS

As in Colombia, distributed generation integration based on optical fiber is useful for countries with prior investments in fiber networks which is a sustainable solution for the incorporation of new technologies because it has many advantages especially in the reliability of communications between nodes of distributed generation and control centers

The right time to incorporate optical fiber networks is when the medium voltage feeder circuit of the distributed generation is being installed, because in this scenario the CAPEX is the minimum required.

Once optical fiber has been installed, the useful life of this infrastructure is akin to the expected one for the electric network, which is a great advantage of this technology over other options

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