Study Committee C5

Electricity Markets and Regulation C5

Paper ID_10174

Innovative markets for mutual sharing assets of electric distribution power and data transmission in fiber optic infrastructure

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Motivation

- Optical fiber is the best means of data transmission to meet Smart Grid communication requirements in the electrical sector (high broadband, low latency, no RF interferences, intrinsic cybersecurity, etc.)
- To add more one way to expand optical fiber that it can bring many other benefits with tangible and intangible gains to utilities and society.
- NY-USA-1880, the problem of sharing cables, energy power and telecommunications, on poles in cities has been around for over 100 years (see Figure 1).

Figure 1 - A critical view of the concept of Synergic Networks: (a) the old problem of sharing cables on poles, (b) the sharing problem persists and (c) the new topology proposed for Synergic Networks in test at UniverCemig.

Objects of investigation

In the data communications sector, beyond competitiveness, the synergic network can reach:

- New possibility to install optical fibers in sharing assets of the electric energy sector (see Figure 2);
- Rural or remote locations to provide differentiated services according to the user profile;
- Replace or integrate several large-area wireless networks, where synergistic networks are being deployed;
- Reduce the OPEX in operation and maintenance (O&M) of its optical fibers network in the high robustness platform of Synergic Network.

Figure 2 - View of depollution urban centers pole in the synergic electricity distribution and data communications networks at UniverCemig site in Brazil.

Scenarios setup

- Two scenarios for use in optical smartgrid are presented that allow the analysis of exploitation models of synergistic network – SN (see Table I).
- The simulated scenarios basically differ in the sharing or not of the excess of 10 optical fibers in the urban grid of Santa Rita do Sapucaí city in Brazil, through the new synergistic cables, that is, phase cables with optical fibers integrated to its metallic core.
- For each of the scenarios, the installation of the SN in its complete 13.8 kV MV configuration was considered, that is, for the urban and rural area.
- Furthermore, the possibility of the distribution network being existent and non-existing distribution network was admitted.

Table I - Comparison of scenarios.

	scenario 1 - Dedicated Fiber Optic	**scenario 2 - Shared Fiber Optic**
	Own use by the distribution company	Surplus sharing own use
REVENUES	Recovery of investment made through the energy distribution tariff	
	Digitization is expected that the continuity indicators will improve	
CAPEX	Distribution company	Distribution company and third part company
OPEX		
BENEFITS	---	gained arising from the sharing of the excess of 10 optical fiber

Conclusion

- It was observed that single-phase SN presented lower DCF values for all of the analyzed scenarios when compared to conventional networks (distribution network with fiber optical cable installed in the pole sharing area).
- In the case of new or replace the single-phase SN the simulation results make it always more interesting from an economic point of view than conventional networks.
- When the MV distribution network is already installed, the replace it for SN presents a higher CapEx than conventional network.
- But when looking at OpEx, the opposite occurs due to the fact that expenses with O&M are lower than conventional network, since labor cost is sharing in two companies.

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Model of the proposed scenarios

- The valuation model of the economic benefits of replacing the solution of conventional distribution network by SN is presented (Table II), whose results are expressed by the savings generated by this remodeling within a defined planning horizon, represented by the Net Present Value (DCF).
- The quantification of these savings also presupposes the establishment of a set of financial assumptions about the costs of SN including installation and O&M costs as well as, in the case of scenario 2, the additional revenue from the demand for telecommunications services in the regions where SN are implemented.
- In a schematic way, it is assumed that the valuation model for the proposed scenarios is composed, in a simplified way, by three steps as indicated.
- Economic indicators parameters in Brazil:
  - Rate of return: 7.32%
  - Analysis horizon: 28 years related with Brazilian regulation.
  - Lifetime of cables, optical muffles and splice boxes: 28 years
- Taxes on gross revenue:
  - ICMS: 18% (MG)
  - FUST: 1%
  - Funttel: 0.5%
  - PIS/Pasep: 3.65%
  - Tariff modality: 30%
- Case of reference: Replace all distribution network in Santa Rita do Sapucaí/MG/BRA city.
  - Urban MV Network: 67 km;
  - Rural MV Network: 254 km.

Determine the expenses

- The strategy of determine the expenses involved known costs referring to conventional distribution network (Table III) with the use of fiber optic cable in shared pole space establishing premises for this.
- Initially, the costs related to the implementation of distribution network and conventional fiber optic cable were raised, with suppliers of these two networks separately.
- it is hypothetical estimated that 10 optical fiber will be made available for the data market, only in the urban area. Finally, it is admitted that the SN installation and O&M costs in MV represents 60% of the sum of its same separate costs of distribution network and conventional fiber optical networks.

Table II – Steps in the valuation model of the proposed scenarios.

Specification of modeling parameters	estimate of earnings and benefits	modeling, results and analysis
definition of the reference topology	Synergic network cost (labor, materials, accessories)	development of the valuation model
Parameter choices - economic perspective	Conventional network cost (labor, materials, accessories)	determination of net present value (Capex + Opex)
definition of the analysis horizon	arbitration of unknown parameters	comparison of scenarios
Ways of implementation	tangible earnings estimates	sensitivity analysis

Table III – Expenses with labor and materials for the implementation of MV of SN

Labor expenses in Medium Voltage
Remove cables on conventional: considering 30% of installation cost
Install synergic cables: considering equal to the cost of installation traditional cables
Install optical & electrical insulators [12]: 3% of MV installation cost
Install accessories and join: considering equal to the cost of installation traditional ones
recurring expenses (O&M): considering 8% of MV installation cost per year
Materials
OPPC MV cables 24 F.O.: considering 80% of the sum of cost of traditional (MV cable and fiber optic cable)
Join Optical Box: considering equal to the cost of traditional one
Optical & electrical insulators: considering 4X times the cost of traditional one
Economic Benefits
Recovery of investment made through the energy distribution tariff and optimize O&M cost: considering 70% of the sum of O&M cost of traditional (MV and fiber optic networks)
Gained arising from the sharing of the excess of Urban optical fiber (only scenario 2). Assuming that the monthly price of a shared fiber urban is US$ 60 per km.

Modeling, results and analysis

- In possession of all expenses and benefits established for each of the scenarios, it is possible to determine the minimum total cost of ownership (TCO) to analyzed with the discounted cash flow (DCF) method of each one, whether those involving SN, as well as comparisons with conventional distribution network with separate fiber optical cable.

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Results

- To assess the viability of SN simulations in scenarios 1 and 2 considered, two case studies were prepared using the distribution network of the city of Santa Rita do Sapucaí - MG, which it has the concession of Cemig Utility.
- In both studies, it is considered that the distribution network are installed in a single stage, that is, in year 1 of the analysis horizon.
- Table IV shows the normalized values for single-phase and three-phase SN simulated. The normalized value "1.00" represents the simulated total cost of CAPEX and OPEX of Conventional Distribution Network plus fiber optical cable installed in the pole shared space in the Santa Rita do Sapucaí city in DCF of 28 years.

Analysis of results

- In the case of new or replace the single-phase SN the simulation results make it always more interesting from an economic point of view than conventional distribution network.
- When the MV distribution network is already installed, the replace it for SN presents a higher CapEx than conventional network, since it is only necessary to implement a fiber optical cable network fixed to the existing pole of distribution network. However, when looking at OpEx, the opposite occurs due to the fact that expenses with O&M are not optimize in conventional network, since labor cost is separated in two companies.
- It was observed that for scenario 1 (dedicated fiber) when only replace three-phases the DCF is negative compared for the existing distribution network installed F.O. cable in pole shared space.
- In scenario 2 (shared fiber), the DCF is always positive as a result of the revenues arising from the availability of excess 10 fiber optics to the data market in urban area.
- The evolution of Electricity Markets with smart grid telecommunication technologies are required to accelerate the materialization of the end-to-end efficiency energy in order to: (i) decrease the cost of Electricity in Markets, (ii) increase the number of suppliers and clients into the Electricity Markets, and (iii) sector regulation and tariff design opportunities in the face of technological disruption. These three main dimensions of gains desired are showed in Table V.

Table IV – Normalize DCF of MV Implementation and O&M of SN (Urban and Rural)

DCF (28 years)	Conventional Distribution Network	Synergist Network configuration	Synergist Network scenario 1 (dedicated fiber)	Synergist Network scenario 2 (shared 10 fibers in Urban)
New MV (Urban + Rural)	new MV + F.O. cables in pole shared space. (1.00)	single-phase	(0.75)	(0.41)
		three-phases	(0.94)	(0.61)
Exist MV (Urban + Rural)	install F.O. cables in pole shared space (0.79)	replace single-phase	(0.68)	(0.35)
		replace three-phases	(0.98)	(0.64)

Table V - Three dimensions of main gains desired in of Electricity Markets of Synergic Network

Dimension of gain desired
decrease the cost of Electricity Energy: The evolution of energy and telecommunication technologies in synergy way accelerates the optimization of O&M procedures. The Synergic Network shares its assets causing huge financial gains the Electricity Market.
increase the number of suppliers and clients into the Electricity Markets: Open the electricity market for improve competition.
sector regulation and tariff design opportunities in the face of technological disruption: The smart grid network needs to be implemented faster than now in order to expand Electricity Market in the electricity sector.

Conclusion

- It was observed that single-phase SN presented lower DCF values for all of the analyzed scenarios when compared to conventional networks (distribution network with fiber optical cable installed in the pole sharing area).
- In the case of new or replace the single-phase SN the simulation results make it always more interesting from an economic point of view than conventional networks.
- When the MV distribution network is already installed, the replace it for SN presents a higher CapEx than conventional network.
- But when looking at OpEx, the opposite occurs due to the fact that expenses with O&M are lower than conventional network, since labor cost is sharing in two companies.