Conference Proceedings

Solar World Congress 2015
Daegu, Korea, 08 – 12 November 2015

PROTECTION OF ELECTRICAL DISTRIBUTION SYSTEMS BY SMART GRID, CONSIDERING SOLAR PHOTOVOLTAIC GENERATION

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Abstract

According to resolution 482 of the Brazilian National Electric Energy Agency (ANEEL), connection of micro and mini generation directly on power distribution grids are now possible in Brazil, in both cases only from renewable sources. This resolution provides that each customer can have a photovoltaic system producing energy to complement the own consumption and can inject the excess energy in the power grid, establishing a power compensation cycle, with credits valid for some months (net metering). Massive connections of distributed micro and mini generation demands a centralized control and an intelligent management system that only will be possible with use of smart grid technologies, including telecommunications infrastructure, computing facilities, smart metering and advanced protection/automation. This paper presents an assessment of impacts on the protection in electrical power distribution systems when micro and mini generators are connected on grid, considering solar photovoltaic and smart grid concepts.

Keywords: Smart Grid, Protection Grid, PV connect on Grid, Solar Energy, Distributed Generation,

1. Introduction

Power generation by photovoltaic panels, is a widely used technology in Europe and the United States. The great motivation for use of this technology is the reduction of environmental impacts, as well as, the attractiveness of generation systems using distributed, low voltage, as shown in research carried out by Angelopoulos (2004) and Guan, et al. (2009) on the integration of distributed generation in low voltage circuits and their impact on power systems, analyzing power quality and the technical and economic feasibility of the connection.

As the resolution 482, it is possible to micro and mini connection generation distributed electricity from renewable sources, with the low voltage electrical grid. The publication of this resolution is a regulatory framework in Brazil. This resolution states that each client, whether residential, commercial or industrial, may have on the roof or other location of your unit consuming a photovoltaic central producing energy to complement the own consumption. The excess energy is injected into the grid and through the power compensation system used in the subsequent months, the consumer unit or other consumer property. So with the established regulations is underway in Brazil the development of a market with the implementation of various plants, micro and mini generation distributed in consumer units connected to electrical grids of distributors.

According Toledo et al. (2012), the massive connections of micro and mini generation distributed require a control and an intelligent management, which will be possible with the use of smart grid technologies, such as

doi:10.18086/swc.2015.06.03 Available at http://proceedings.ises.org

telecommunications infrastructure, computing, smart metering and protection and automation advanced. According to Toyama et al. (2010), the connection and protection of small generators to operate in parallel with the utility grid present some significant challenges, especially in relation to security and protection of persons and facilities. There are therefore a number of technical concerns about small connected generation systems, such as risks to grid security and other consumers, provided power quality, islanding, frequency variation, harmonic distortion, power factor and influence in action the grid protection systems. The departure from the standards set by rules and procedures characterizes an abnormal condition of operation, and the connection of protection to be able to identify this gap and isolate the systems ceasing the mains power supply.

Before the described scenario, this paper presents an assessment of impacts on the protection of electrical distribution systems by generation micro and mini connection, considering solar photovoltaic generation and smart grid concepts. Article make a contribution to consolidating the micro central connection and mini generation to the electrical distribution grid with reliability and safety of people and facilities, contributing important insights for consumers, equipment manufacturers, installers and electric utilities in Brazil. The article is a master's thesis summary developed / directed by the authors at the University of Pernambuco and Federal Institute of Pernambuco, Recife, Brazil.

2. Overview of smart grids in Brazil

In Brazil, the practical initiatives for implementation of smart grids (REI) are still timid, limited to a number of pilot projects. The implementation of motivation of smart grids in Brazil are: improving grid reliability, improved quality of supply, reduction of non-technical losses of energy, energy efficiency and renewable energy deployment. However, the regulatory framework is being prepared to receive the new technology in the distribution system. Several studies have been and are being conducted by government agencies and the private sector.

The research and development projects in the area of smart grids that are being carried out by partnerships between electric utilities, universities, research centers, laboratories and manufacturers have been important in assessing the performance and benefits resulting from the implantation of REI in Brazil. Including quotes to the strategic project and call cooperated No 011/2010, ANEEL, "Brazilian Program for Electric Smart Grid" which was proposed by CEMIG, with participation of other thirty-six companies and six research institutions, and the coordination of implementation carried out by the Institute of the Brazilian Association of Electricity Distributors (IABRADEE).

According to the Ministry of Science report, Technology and Innovation (MCTI) (2014) and according to data released by the Brazilian Agency for Industrial Development (ABDI) in partnership with the Owning Companies Association Institute for Infrastructure and Private Systems telecom (iAptel), in Brazil there are more than 200 ongoing projects on the KING theme. These initiatives involve about 450 institutions, covering more than 300 suppliers, 126 research centers and 60 concessionaires in the electricity sector, as well as ministries, regulatory agencies and universities. It is estimated that the amount of investments of these types of projects will reach R $ 1.6 billion considering initiatives in the generation, transmission and distribution.

Application of R & D resources in demonstration projects or pilots, ie projects that evaluate the concept of KING on the whole, has given up in the distribution segment, considering that is the most affected sector by the changes arising from the implementation of the REI. Among these projects, according to data from the first half of 2013, more than half of the investments made and planned the projects were part of the stage of the innovation chain: experimental development, showing the importance given by the concessionaires to real trials of the concept of REI.

Figure 1 shows eight of the main statements designs or REI pilots in Brazil. These projects make up an investment made / provided over R $ 200 million, according to 2013 data.

Fig. 1 - Main Projects of REI in Brazil

The first pilot projects have been conducted by Light and Cemig, being followed by others in the industry. Light within the Inova Energy program is developing an REI project with the installation of about one million smart meters, whose main objective is to reduce non-technical losses. So this is the first step to implement the large-scale project in Brazil smart grids.

3. Micro and Mini generation distributed in Brazil

In April 2012, the National Electric Energy Agency (ANEEL) published the resolution in 482 (2012), which establishes the general conditions for access of micro and mini generation distributed to power distribution systems in Brazil.

With the advent of this Resolution was revised module three (3) of the Electricity Distribution Procedures in the National Electricity System (ANEEL) (2013), introducing the section 3.7, guidelines for micro access and mini generation distributed where the requirements are indicated minimum required for generating central connection point. The proposed protection system must be assessed and studied, to identify whether its implementation ensures the sensitivity requirements, reliability and selectivity of the protection of the interconnected distribution system, utilities and micro or mini generation as well as the safety of installations and operating personnel and maintenance.

The resolution in the 482 states that distributed micro (Micro GD) are electric power generating plants, with lower installed power than or equal to 100kW, using sources based on hydropower, solar, wind, biomass or qualified cogeneration, connected to the distribution grid through plants consuming units (RU). Already distributed mini generation (Mini GD) are the power plants with the same characteristics, however, with installed power greater than 100kW and 1MW or less.

In order to enable the micro and mini generation, the resolution in the 482 also established the power compensation system (metering net), in which the surplus active energy injected into the grid, generated by consumer unit with micro or mini generation distributed, compensate the consumer active electricity. The implementation of micro power plants and photovoltaic solar mini generation provides the technical basis for developing the use of solar energy, and build skills to assess the technical and commercial arrangements of small distributed generation with grid-connected photovoltaic systems.

However, by injection directly into electric energy distribution systems, because of the existence of micro central and distributed minigeneration, these become active systems, may generate energy consumption and at the same time. As is the case for most distribution systems, these were not designed for two-way flow of energy, and, therefore, are likely to have problems with the growth of distributed generation.

According Thong, et al. (2005), the connection of distributed generation (DG) in distribution systems can impact various parameters of these systems, for example, power flow (which now becomes bidirectional), the voltage profile, voltage stability , current imbalances, protective systems and, finally, as a result of these changes, the quality of electricity.

The inclusion of micro and / or mini generation distributed impacts in many processes of a company that distributes electricity, for example: planning, operation, protection study, among others, thus presenting great challenges and requiring new techniques to optimize and operate these systems. According to Cabello and Pompermayer (2013), in Brazil, the legislation only allows access to the electrical system of the central distributors of micro and renewable mini generation and not allowed these plants operate in isolation, but in an integrated way, reason in which shall be automatic devices which prevent "islanding" ie when the automated system of micro and mini generation detecting a power failure from the grid should automatically disconnect and interrupt the supply of power from generation of the consumer unit to the grid distribution. Brazilian law also does not allow the direct sale of the energy generated, just compensation through credits, the slaughter of consumption. The production of electricity from solar photovoltaic systems today is among the generation of alternatives, the most viable technical and economically, to the core of micro and mini generation, as a direct result of the fall in the price of photovoltaic modules, good availability, speed and ease of installation.

It should be noted that the deployment, operation and maintenance of micro centers and distributed mini generation as well as their connection to the electrical systems of distributors must meet the requirements of standards and regulatory regulations issued by the competent bodies, since they dictate rules to be followed by those involved, party accessing (owner of consumer micro or mini generation) and accessed (electricity distribution), so that the interconnected micro or mini system generation x distributor to operate safely and reliably meeting all the technical requirements.

4. Assessment of Impacts on the Protection of Electrical Systems Distribution Micro Centers connection and Mini generation Solar Photovoltaic

This topic assess the impacts on the protection of electrical distribution systems of micro central connection and photovoltaic solar mini generation considering the security aspects and operation of facilities as well as the operation and maintenance personnel involved and the concepts of electrical smart grid.

4.1 Initial considerations

The increasing penetration of micro plants and mini generation brings new challenges for the planning, operation, maintenance, protection and control of electrical distribution systems. Currently, most electrical distribution systems in Brazil, operates radial configuration, that is, energy flows in one direction. The implementation of micro centers and distributed mini generation changes the system topology, passing the energy to flow in several directions, impacting the protection of electrical distribution systems. The current distribution protection systems use simple schemes based on switches and fuses, sectionalizers, reclosers line and substation, associated with overcurrent and automatic reclosing relays. These simple schemes may require adjustments and upgrades to support the connection of micro and minigeneration centers. According to the Institute of Electrical and Electronics Engineers (IEEE) (2004), advanced protection schemes that can adapt to changes in the distribution system configuration can be essential for distributed generation plants connection. They will depend on the data collection in strategic locations and communication of data between intelligent relays for distribution system protection, through the protection to be an integral part of the automation of distribution systems. Great micro central numbers and mini generation can bring problems of stability and frequency control, just a few issues that are relevant in the generation and transmission systems

become relevant also in the electric distribution system. However, new automation technology, protection, control, communication and information systems, applied to electrical distribution systems will bring many benefits to the operation, supervision and monitoring system, improving the quality of power supply to customers.
Next is to assess the impacts on the protection of electrical distribution systems micro central connection and photovoltaic solar minigeneration, using inverters to transform the direct current generated in PV modules into alternating current. It makes up the assessment comparing the distribution system with and without the central considering the topology, currently adopted by the distributors, specifically the Energy Company of Pernambuco (CELPE), distributor of electricity in the state of Pernambuco. For example, using distribution transformers with delta connection, in 13.8kV, the side of the distributor and grounded wye, 380 / 220V, the side of the consumer units (loads). All evaluations are carried out considering the distribution of figure 2 circuit, the data presented in Table 1.

Figure 2 shows the Jordan River substation Celpe 69 / 13.8kV-10 / 12,5MVA three feeders, be simulated in the feeder 2, the connection of a central microgeneration 71,91kWp and mini generation center 989, 82kWp. The central micro and mini generation were designed based on the maximum values adopted by CELPE (2013 and 2014) for micro connection and mini generation, based on the resolution at 482. The maximum values were chosen to simulate the extremes of micro connection and distributed mini generation.

For simulations we considered the central microgeneration 71,91kWp made up of eighteen (18) photovoltaic series in parallel, each series with seventeen (17) Solar modules from Bosch. The connection to the grid is performed by a three-phase central inverter with an output of 75kW. For simulations it considered the center of mini generation 989,82kWp formed by 234 (two hundred thirty-four) photovoltaic series in parallel, each set with 18 (eighteen) modules from Bosch Solar. The connection to the grid is performed by a three-phase central inverter with an output of 1000kW.

Tab. 1: The electrical distribution system data

Components of the Distribution System	Impedances (pu base of 100 MVA and voltage system)		
	Positive sequence (Z_1)	**Negative sequence (Z_2)**	**Zero sequence (Z_0)**
Equivalent system equivalente 69kV – SE Rio Jordão	0,0331+j0,1222 pu	0,0331+j0,1222 pu	0,0610+j0,5221 pu
Transformer 69/13,8kV -10/12,5MVA	j0,6716 pu	j0,6716 pu	j0,6716 pu
Transformer 13,8/0,38kV -1,0MVA	j7,5 pu	j7,5 pu	j7,5 pu
Transformador 13,8/0,38kV -0,15MVA	j23,33 pu	j23,33 pu	j23,33 pu
Cable 185mm^2 -AL	0,1107+j0,1359(pu/km)	0,1107+j0,1359(pu/km)	0,2041+j1,3623(pu/km)
Cable 70mm^2 -AL	0,2984+j0,1559(pu/km)	0,2984+j0,1559(pu/km)	0,3914+j1,4022(pu/km)

It is noteworthy that the distribution grid shown in Figure 4 has aluminum cable protected in the primary, and the trunk line in the 185mm2 section and the lead in the 70mm2 section. The secondary grid has aluminum multiplexed cable in the 120mm2 section.

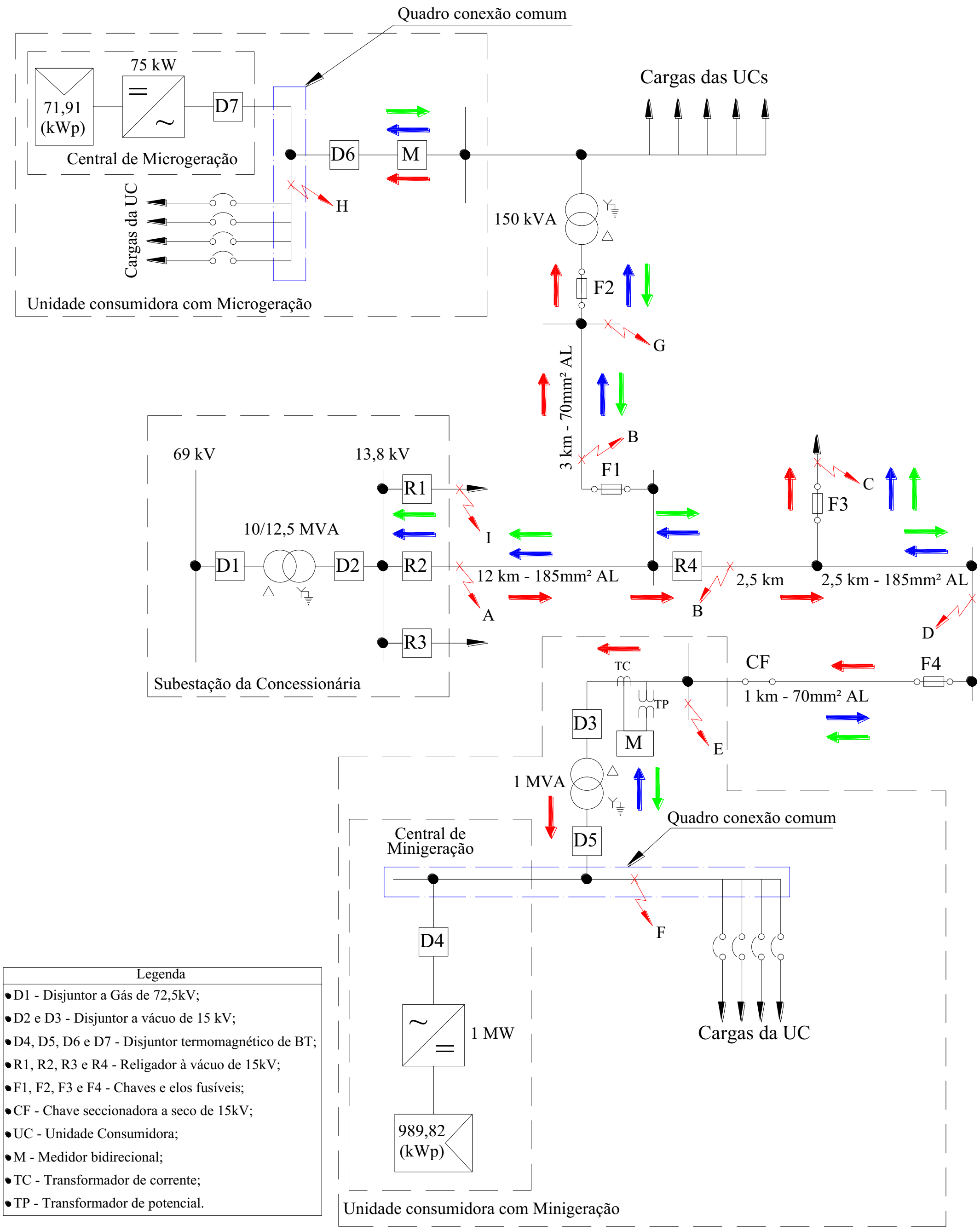

Fig. 2 - Distribution system - ways of short-circuit currents

4.2 Evaluation of short circuit of the electrical distribution system with connection of micro and mini generation.

When you have central micro and / or mini generators connected to the distribution gridsnetwork, their short-circuit levels have changes due to redistribution of possible fault current sources in the feeder. This change may cause undesirable effects in the operation and coordination of protection of the electrical distribution system, considering that proper coordination of relays, reclosers, fuses, sectionalizers is based on contribution to current lack of available sources that feed the defect. It is desirable to maintain a good coordination of relays, reclosers and fuses on the utility system with and without the core of micro and mini generation connected to the network.

According Sidhu and Bejmert (2012), the central micro and / or mini generation can be represented by a Norton equivalent circuit, where it has an ideal current source, a diode, and a resistor connected in parallel with the current source and resistor in series.

To calculate the short-circuit fault point of current, whereas the central micro and / or mini generation there is shown the system of distributing the Thevenin equivalent circuit at the point and the sources of micro and / or mini generation the equivalent circuit Norton and through the superposition theorem obtaining the total fault current.

For the circuit of Figure 2 were calculated short-circuit currents in given points, using the program: Analysis of simultaneous faults (ANAFAS) developed by Cepel. The ANAFAS is a interactive and friendly tool for analyzing faults in electrical systems, allowing the modeling system (prefault loading, representing the capacitance of the lines and loads, etc.) and the simulation of different types of defect that can be defined for compounds of simultaneous faults.

In Tables 2 and 3 show the results of simulation of a short circuit, three-phase, two-phase, open and single-phase single phase with 40Ω of contact resistance, showing the contributions of the Celpe system, Central micro and Central mini generation. It is noteworthy that the contributions of micro GD and mini GD were calculated considering that at the time of short circuit they are injecting all power on the network.

According Katiraei, et al. (2012), the central contribution of micro and / or mini generation to lack depends on the inverter design, and in most models can reach up to 120% of rated drive current. For the simulations presented considered for contribution of micro plants and mini generation this maximum value, é 120% of rated current of inverter 75kW and 1000kW.

The results shown in Tables 2 and 3 show that the contributions of the central micro GD and mini GD and for the current total short circuit, at various points of simulated faults when they occur in the medium voltage (13.8 kV) is very small and to zero if the defect is phase-ground due to the delta connection on the high side of the transformer Celpe and the high side of the transformer consuming unit mini GD, given that due to the transformer connection, there zero sequence component. The results also show that the system Celpe source of contributions are significant, especially when the short circuit is three-phase or two-phase and occurs in low voltage on the AC side.

It is noteworthy that in the medium voltage contributions of the central micro and / or mini generation for short circuits and three-phase two-phase currents are small due to the same are connected to the low voltage side; therefore, the values should be reflected for medium voltage using the transformer turns ratio, as shown in Table 2. To short-circuit the low voltage on the DC side of photovoltaic solar plant, do not have Celpe source contribution, given that the drive does not work as a rectifier.

Tab.2: Results of short circuit current, three-phase and two-phase

Point of Short Circuit	Short Circuit Current (A)							
	Three-phase				Two-phase			
	Celpe	MicroGD	MiniGD	Total	Celpe	MicroGD	MiniGD	Total
A	5.270	3,77	50,21	5.324	4.568	3,77	50,21	4.622
B	1.500	3,77	50,21	1.554	1.300	3,77	50,21	1.354
C	1.300	3,77	50,21	1.354	1.127	3,77	50,21	1.181
D	1.150	3,77	50,21	1.204	997	3,77	50,21	1.051
E	1.060	3,77	50,21	1.114	919	3,77	50,21	973
F	13.830	137	1.823	15.790	11.986	137	1.823	13.946
G	1.140	3,77	50,21	1.194	988	3,77	50,21	1.042
H	5.770	137	1.823	7730	5.001	137	1.823	6961
I	5.270	3,77	50,21	5.324	4.568	3,77	50,21	4.622

Tab. 3: Results of short-circuit currents, single-phase frank and single-phase with 40Ω of contact resistance.

	Short Circuit Current (A)	
	Single phase frank (Ro = 0)	Single phase with contact (Ro = 40Ω)

Point Short Circuit	Celpe	MicroGD	MiniGD	Total	Celpe	MicroGD	MiniGD	Total
A	5.550	0,00	0,00	5.550	199	0,00	0,00	199
B	560	0,00	0,00	560	175	0,00	0,00	175
C	470	0,00	0,00	470	170	0,00	0,00	170
D	410	0,00	0,00	410	164	0,00	0,00	164
E	380	0,00	0,00	380	161	0,00	0,00	161
F	15.530	137	1.823	1.7490	5	137	1.823	1.965
G	440	0,00	0,00	440	165	0,00	0,00	165
H	6.000	137	1.823	7.960	5	137	1.823	1.965
I	5.550	0,00	0,00	5.550	199	0,00	0,00	199

According to Sidhu and Béjart (2012), when the PV plant is well protected (overcurrent, overvoltage, anti ilhamento) their contribution to fault current is also limited in time. For this reason there is no problem with the coordination of protection when a high-powered photovoltaic power plant is connected to the distribution grid. However, the distributor of the operation should be careful when the photovoltaic penetration level is high; in this case it is recommended to conduct special studies for the feeder and some coordination with directional relays may be required.

When the short circuit occurs in the low voltage from the point of view of the concessionaire, independent of whether or not central micro and / or connected min Generation for the micro and / or mini generadores acessantes, it is recommended to check the suitability of the breaking capacity of their protective equipment, circuit breakers and fuses.

4.3 Evaluation of Micro and Mini generadores connection in relation to the Coordination and Selectivity Protection

The evaluation of micro central connection and mini generation, regarding the coordination and selectivity of protection of electrical distribution systems, is performed based on the circuit of Figure 2. It is considered that without the plants, the protection is set, serving the criteria established by the concessionaires, according to the settings in Table 4.

Tab. 4: Settings of protection devices

Substation or Grid/ Equipament	Voltage (kV)	RTC (A)	Phase Protection		Neutal Protection	
			Manufacturer and type	Setting	Manufacturer and type	Setting
SE Rio Jordão Recloser 21J1	13,8	800-5	ZIV 8IRV	Tap: 480 A	ZIV 8IRV	Tap: 48 A
				Eq: 480 A		Eq: 48 A
				Cur: I0,14		Cur: M0,4
				Inst: 3200A		Inst: 1600A
SE Rio Jordão Recloser 21J2	13,8	800-5	ZIV 8IRV	Tap: 480 A	ZIV 8IRV	Tap: 48 A
				Eq: 480 A		Eq: 48 A
				Cur: I0,14		Cur: M0,4
				Inst: 3200A		Inst: 1600A
SE Rio Jordão Recloser 21J3	13,8	800-5	ZIV 8IRV	Tap: 480 A	ZIV 8IRV	Tap: 48 A
				Eq: 480 A		Eq: 48 A
				Cur: I0,14		Cur: M0,4
				Inst: 3200A		Inst: 1600A
REDE Recloser R_4	13,8	600-1	Arteche Smart RC P500	Tap: 240 A	Arteche Smart RC P500	Tap: 30 A
				Eq: 240 A		Eq: 30 A
				Curva: 0,10		Curva: 0,2
				Inst: 1440A		Inst: 480A

Reclosing relays (79) and the fuses are set as follows:

- ✓ number of apertures (NA): 3;

- ✓ number of reclosing(NR): 2;
- ✓ intervals reclosing: 1o 7s e 2o 7s;
- ✓ time of reset: 120s
- ✓ fuse link F1: 40k
- ✓ fuse link F2: 8k
- ✓ fuse link F3: 50k
- ✓ fuse link F4: 80k

In Figure 2 the arrows in red color represents the Celpe substation contribution to short circuits and arrows in blue and green colors represent the contribution of the central mini generation and micro respectively. With the micro connection and / or distributed mini generation feeders, the values of short circuit currents considered fuse and recloser operation will be changed. Then, to the circuit of Figure 2 analyzes the coordination and selectivity of network protections for short circuit in the various points shown in the figure.

4.3.1 Short-circuit at point A or AB grid

In the short-circuit point A or AEB grid must be eliminated by R2 recloser, whose performance conditions do not change with micro central connection and mini generation. However, it has been contributing to the short circuit of micro and mini generation plants, until the R2 recloser open and plants are disconnected for lack of tension. Thus, one should assess whether the fuses F1 and F2 keys support the short-circuit current from Central micro and R4 recloser settings and the key fuse link F4 support the short-circuit current from the central mini generation, thereby avoiding the undue opening of these protection devices. By evaluating the values of short-circuits shown in Tables 2 and 3, and R4 recloser settings and the nominal values of links, it can be stated, for the example given, which does not have any problem, but for a greater amount of core It may need to make some adjustments in these protective devices.

4.3.2 Short-circuit at point B and BDE grid

Short circuits at point B, after R4 recloser or BDE network must be eliminated by R4 recloser, whose performance conditions do not change with micro central connection and mini generation and may even improve as short chain passing the R4 recloser is the sum of the Celpe contribution to the Central microgeneration. However, it has been contributing to the short circuit Central mini generation until the R4 recloser open and the center is disconnected for lack of tension. Thus, one should assess whether the F4 key fusible link supports the short-circuit current from the central mini generation, thereby avoiding the undue opening of these protection devices. Assessing the short-circuit values shown in Tables 2 and 3 and the nominal value of the bond, it can be said, for our example, there would be no problem, but for a larger number of plants can be necessary to make some adjustment in this protection device.

4.3.3 Short-circuit at point C

Short circuits in C must be disposed of by the key fusible link F3, so be selective with the R4 recloser, to test if the defects are temporary or permanent. With the connection of micro power plants and minigeneration has contributions from central to short circuits, however, while the micro central contribution through the R4 recloser contributing to improve the sensitivity of protection, the central contribution of minigeneration no more R4 in recloser, which may cause the selectivity between the fuse F3 key and R4 recloser is lost. With the connection of power stations, utilities must well evaluate the selectivity of the protections of extensions with fusible link and reclosers. Due to the small contribution minigeneration center for short, as shown in Tables 2 and 3, it can be stated, for the example given, which does not have any problem, but to a larger number of plants and to a system with low currents short circuits, rural feeders may be necessary to change settings of reclosers or replace the extension of fuses for seccionalizador or recloser.

4.3.4 Short-circuit at point B and BG grid

Short circuits at point B after the fuse F1 key or BG network must be eliminated by F1 recloser, so be selective with the R2 recloser, to test if the defects are temporary or permanent. With the connection of the central micro and mini generation has contributions from central to short circuits until the R2 recloser open and plants are disconnected for lack of tension. Thus, one should assess whether the F2 key fusible link supports short-circuit current from Central micro and R4 recloser settings and the key fuse link F4 support the short-circuit current from Central mini generation, thereby avoiding the undue opening of these protection devices. The mini generation central contribution fails the recloser R2, which may cause the selectivity between the fuse F1 key and the recloser R2, is lost. As noted above, with the connection of power stations, utilities must well evaluate the selectivity between protections extensions with fusible link and reclosers. Due to the small contribution minigeneration center for short, as shown in Tables 2 and 3, it can be stated, for the example given, which does not have any problem, but to a larger number of plants and to a system with low currents short circuits, rural feeders may be necessary to change settings of reclosers or replace the extension of fuses for seccionalizador or recloser.

4.3.5 Short-circuit at point I

Short circuits in point they must be eliminated by the recloser R1, whose performance conditions do not change with micro central connection and minigeneration. However, it has been contributing to the short circuit of plants and micro minigeneration until the open recloser R1. In this situation, the central remain connected, because the short-circuit occurs in an adjacent tray. However, it has short-circuit current passing in the opposite direction R2 and R4 reclosers. Thus, one should assess whether the currents flowing in the opposite direction to normal load flow, by R2 and R4 are enough to make the protection work by turning off all or part of the load feeder 2, which characterizes lack of selectivity protection. To solve this problem you should use directional overcurrent relays in the protection of reclosers substations that have a high amount of core micro and minigeneration. It should be noted that the opening of R2 or R4, and stop the service consumers or cause undesirable ilhamentos hampers the fault location, increasing the time of the interruption and the cost of maintenance.

4.3.6 Short-circuit at point F and H

Short circuits in F and H points are defects that occur in consumer units, where the plants are installed, and must be eliminated by D6 and D7 Breakers to the central micro and D5 and D4 to the central minigeneration. For those short, the contribution of Celpe for short is added to the central contribution; therefore, should be assessed to the new situation the breaking capacities of circuit breakers remain adequate. The influence of the central contributions to the defect, circulating on the medium voltage grid.

5. Conclusion

In the assessments it was observed that the micro central connection and / or minigeneration in distribution system designed to feed the radially load may bring a number of problems with the coordination of the protective devices, because the actual distribution system It has several load leads over the circuits may have more than one protective device on the line between the substation and the central connection.

The example showed that for connecting small amount of core micro and / or mini generation the influence in protection systems is not significant, but for mass connection, the protection system of distribution and transformer feeders should be well assessed through coordination studies of protection. Micro connections and / or distributed mini generation should take the utilities to make adjustments in the distribution protection systems, so that system performance is not reduced, which will probably lead to the implementation of smart grid technologies.

The assessments also show that the addition of plants and micro mini generation distributed to a distribution system has the potential to impact protection and beyond the point of common coupling. The greatest concern are the effects on the protection systems traditionally designed for radial operation. Among the issues that must be considered has two-way flows, increased fault levels, safety, voltage control, equipment capacity, automatic restart, islanding and coordination and selectivity. These effects are not limited to grids in which the control panel is connected, and can affect the relay protection in adjacent grids as well. Thus, careful studies to identify and solve these problems are needed whenever a plant is added in order to ensure continued safe and reliable operation of the system.

The implementation of smart grid technologies that enable communication between protection devices, enabling the control and supervision of the interconnected utility system with the center of the party accessing, enabling direct disarm distributor breaker Central micro or mini generation, will bring greater reliability and security for system operation and maintenance.

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