PROTECTION, OPERATION AND VOLTAGE REGULATION EQUIPMENT FOR SERVICE QUALITY

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INTRODUCTION

The Quality Service requirements contained in the Concession Agreements of power distribution companies in the Argentine Republic have made it necessary for these utility to make significant investments in the distribution network to reach the levels of Quality Service demanded for each quality stage.

This paper presents two methodologies tending, on the one hand, to improve the fault response time that affects large users, thus diminishing the penalties that are applied to the utility company; and, on the other hand, to mitigate permanent overvoltage – 1.5 minutes – generated by the action of the transitory fault protection equipment in sub-transmission primary networks which have several voltage regulator banks in cascade installed downstream.

1. OPTIMIZATION OF PROTECTION AND MANEUVERS DEVICES

1.1. Introduction

After three whole semesters of quality measurement at user level and considering the penalties applied to the utility company for failing to reach the quality levels required, it was determined that the protection strategy had to be changed, taking into account the location of large users and the possibility of providing support in the shortest possible time in case of any failure in the distribution network.

Based on the analysis carried out on the existing reclosers and sectionalizers, the number of operations performed by them, the location and type of large users and the penalties applied to the utility company, the relocation of some equipment and the acquisition of new equipment for the telecontrol of other equipment already installed was determined.

1.2. Control of the Quality of Service

The quality control of the technical service and product in Energy San Juan, was developed in three stages. A preliminary stage of adjustment and adaptation of the different involved systems – electric and information systems – without penalties.

The second stage denominated “Stage I of Control”, the quality control the was carried out through global indicators to level of centers of transformation of MT/BT and bars of power stations.

The control indicators were in function of the quantity of transformers and installed power of the centers of transformation of MV/LV installed in the net. Of this calculation methodology, the convenience was determined of avoiding the exit of service of big modules of installed power, being one of the parameters for the determination of the initial location of reclosers and switchgears.

In the Stage II of Quality Control, third established and at the moment effective stage from the year 2002, the control is carried out on each supply. Global indicators are not determined, but rather, taking an itemized details of the diverse contingencies – you fail or maneuvers – of the distribution net, so much of high, mediates and low voltage, and reflecting the same envelope the electric GIS, the interruptions and time are determined outside of service of each one of the users of the distribution network.

If in the controlled semester an user suffered more courts – bigger to 3 minutes – and was without supply more time than the suitable ones in the precedent charts, will receive on behalf of the utility company a penalty valorizing the not given energy that is in function of the duration of each interruption of service, of the moment of the day that takes place and of the energy billed annually by the user.

1.3. Distribution Electric System of Energía San Juan

Energía San Juan has a distribution system that embraces different levels of voltage: High Voltage (132 kV), Medium Voltage (33 kV and 13,2 kV) and Low Voltage (0,4/0,231 kV).

It is supplied mainly of the Wholesaler Electrical Market Argentinean (SADI) through two lines of high voltage in 132 kV and 220 kV, with a maximum demand operated in the year 2004 of 197 MW.

Also, it possesses two isolated systems in the Departments Valle Fertil and Calingasta whose demand maxim is respectively 1,5 MW and 1,7 MW.

We can summarize the physical facilities in the following Table Nº 1:
It has a system SCADA that allows telecontrol and monitor the entirety of the transformer stations of HV/MV and MV/MV, besides 57 of the 90 equipments, among reclosers and sectionalizers that are installed strategically in the distribution network.

1.4. Reclosers and sectionalizers use

The use of the medium voltage reclosers is bounded, mainly, to the clearance of transitory faults that would take to a permanent cut with the use of teams fuses. They have also settled in the positions of mensuration of big demands (bigger to 1.000 kW) allowing a correct adjustment of the protection systems.

The sectionalizers is located in the points of interconnection of feeders of medium voltage, operated “Normal Open”, or strategically in intermediate points of the feeder, operated “Normal Closed”. Through detecting in passing of faults, it can be determined and to isolate the failed tract and providing support at one time the rest of the users relatively brief.

The rules that were continued for the Reclosers installation and sectionalizers were related with areas of problems of having hoisted and areas with big transformation power installed. The objective is to minimize the exit of big modules of installed power, and in the case of being unavoidable the exit, to have the possibility to support the biggest quantity in power in the smallest possible time.

1.5. Penalties for bad Quality of Service

After three whole semesters of quality measurement at user level supply, the total of penalties that should recognize Energía San Juan to the different users, justifies to carry out an analysis in order to determine the form of improving the quality of service in this new stage and, consequently, to diminish the penalties that it is object the utility company.

The biggest penalties received them the big users, and, of their analysis, you reached the conclusion that the attention should be focused in minimizing the time outside of service and the quantity of the big energy consumers’ interruptions.

1.6. Analysis of the penalties for each user and operation of the Reclosers

Analyzing the penalties perceived by each one of the users, between 70% and 80% of the total of the penalty was distributed among few users with big demands. Identifying these users inside the electric system and analyzing the reasons of each one of the exits, you could infer where new reclosers could be needed that allowed a quick reestablishment of the service of these users.

On the other hand, the operation statistic was analyzed of each one of the reclosers and sectionalizers, with the penalty associated to each one of the operations.

Of the analysis of the statistic, those teams were selected whose location is inadequate for the objectives of quality of service that are pursued, either for that the quantity of carried out operations or the penalty associated to each valorized exit are scarce.

One of the reasons that were in a smaller operation of the reclosers, is the continuous maintenance carried out on the facilities that, in many cases, they took to diminish the origin of the faults substantially that they justified the use of a recloser. This allows to be able to have this equipment to be transferred to another point where it is more necessary.

1.7. Relocation of euipments and necessity of new investments

Of the result of the analysis of the previous point, we took the decision of relocating reclosers and sectionalizers, besides incorporating the necessary equipment for the telecontrol some reclosers.

This decision, beyond having a direct benefit in the quality of important users’ service in the consumption, was analyzed from the point of view of the necessary investments of carrying out, and they were compared with the benefit of penalties reduction by quality of technical service.

The analysis of the convenience of to relocations different equipments and to invest in new equipment, was based on an economic evaluation of each change, considering like benefit the saving in penalties for decrease of the times of reinstatement of the service, versus the cost that means the relocation of the equipments and the investment in new equipment.

In the Table Nº 2 the economic indicators of the project are shown that are calculated in function of the benefit of each one of the movements that were carried out.
1.8. Conclusions

Depending on the methodology of quality control of technical service and of the appraisement of penalties they are objects the utility companies, it becomes necessary to revise the strategies of implemented protection, since it can be necessary that they require adjustments to obtain a good result.

After the analysis of the penalties that has been object Energía San Juan, of the operation of the reclosers and sectionalizers park and of the economic analysis of the necessary investments to optimize the relocation of these equipments, we finished in the necessity to carry out a rotation of some of them that didn't have associate important penalties for their exit of service.

We can mention that the project is in the stage of finalización of relocation of the equipments, for what will be carried out the pursuit of the operations of each one of the reclosers involved in this optimization and the times outside of the users’ service with more penalties in the future.

For the future it is necessary to have present the incorporation of new important clients or the growth of the existent clients, since, not to have an appropriate strategy of protection that assure him a bigger continuity in the supply, can derive in the application of important penalties to the utility.

2. MITIGATION OF PERMANENT OVERVOLTAGE FOR THE USE OF VOLTAGE REGULATORS AND AUTOMATIC RECONNECTION DEVICES.

2.1. Introduction

In this second part, is described the experience of Energía San Juan in the implementation of a control system that allows to mitigate the problems of overvoltage that take place for the interaction among the protection systems and of voltage regulation equipment.

The use of voltage regulators allow to assure the execution of the maximum standards and minima demanded by the control authority for the technical product–level of voltage–when extensive nets of energy distribution exist.

But, in coexistence with systems of protection that have incorporate automatic recloses, problems of surge can exist when the service is restored.

2.2. Description of the system

The present analysis was carried out on it leaves the network of Energía San Juan located approximately to 100 km of the main point of abastecimietno that is the E.T. San Juan. The demand of this area is of the industrial, mainly mining type and, recently, a great growth in demand of agricultural watering.

The electric supply to the area in study is carried out from the E.T. San Juan until the E.T. Pocito in double feeder of 33 kV and 15 km of longitude. From ET Pocito (Figure N°1), through a feeder of 33 kV of a longitude of 52.5 km and finally a line of 33kV from ET Cañadita to ET Los Berros with a longitude of 24.8 km. The lines of a section of 120mm$^2$ and 95 mm$^2$ in driver of aluminum alloy.

The power installed in transformation of 33/13,2 kV in ET Los Berros is of 10 MVA and 5 MVA in ET Cañadita. The maximum demand of the region is presented in summer and it is approximately of 10 MW.

The voltage regulators of the E.T. Los Berros and E.T.
Cañadita is conformed by two or three regulators single phase connected in closed or open triangle.

The E.T. Cañadita possesses two regulators banks, connected in the system of 33 kV and 13.2 kV, the margin regulation is of ±10% concerning the entrance tension in 33 kV (Configuration open triangle “V”) and ±15% in the system of 13.2 kV (Configuration in closed triangle). The E.T. Los Berros have 2 groups of regulators in the system of 33 kV and 13.2 kV with a margin of regulation of ±10% each one.

In summary, the generated overvoltage is due to three factors:

✓ Energization of a very extensive line that capacitiva behaves.
✓ Decrease of the connected load.
✓ Position of the points of TAP of the regulators.

On the other hand, the strategy of the protection system contemplates to carry out recloses in the lines of 33 kV when transitory type faults take place.

The problem is presented when, happened a the fault on the line, the system of protection comes to the opening from the nearest switch to the failed element, and after having lapsed the established time out--generally 5 seconds - you proceeds to make the reclose of the line. If the closing is successful the service is restored, but if the fault persists you proceeds to the definitive opening of the line failed.

The times of response of the banks regulators are such that I lower this extreme situation, permanent surges take place during an approximate time of 1.5 minutes.

In front of the explained problem, we present a strategy to mitigate the overvoltage, which is achieved through an interaction among the telecontrol devices, protection and voltage regulators.

The problems of overvoltages that we want to be described they present after having restored the later service to a reclose, when the state of load of the lines is important.

In a state of normal operation, with important values of demand, the transmission lines present strong falls of tension. This situation makes operate the banks of voltage regulators increasing the voltage in order to reach the reference values, arriving in many cases to maxim of possible regulation.

Produced a transitory fault in a line that has consisted voltage regulators dilutes below and in the condition of maxima load, the current of generated fault causes a fall of voltage additional due to the lower short circuit levels in the network. This situation causes an important loss of the load, as a consequence of the adjustment of the protection that have the users to protect its facilities.

In the case of the regulators banks, they are adjusted with the maximum tap changer, that is to say, hoping the voltage of the side source is minimum.

Carried out the reclose transitory overvoltage values are generated and also permanent overvoltage, since the time of reaction of the regulators banks doesn’t allow to adjust the output voltage in instantaneous form. This causes serious inconveniences in the supply, mainly breaks of electric devices in the non disconnected users.

2.3. Description of the problem

The electric power supply through a distribution networks, presents the inconveniences that possess the radial networks of extensive longitude: big falls of voltage and lower short circuit levels.

In the following graphs, it is shown the evolution of the energization of a very extensive line that capacitiva behaves.

The problem is presented when, happened a the fault on the line, the system of protection comes to the opening from the nearest switch to the failed element, and after having lapsed the established time out--generally 5 seconds - you proceeds to make the reclose of the line. If the closing is successful the service is restored, but if the fault persists you proceeds to the definitive opening of the line failed.

In summary, the generated overvoltage is due to three factors:

✓ Energization of a very extensive line that capacitiva behaves.
✓ Decrease of the connected load.
✓ Position of the points of TAP of the regulators.

In the following graphs, it is shown the evolution of the demand and the voltage with the effect that takes place after a reclose.

In a state of normal operation, with important values of demand, the transmission lines present strong falls of tension. This situation makes operate the banks of voltage regulators increasing the voltage in order to reach the reference values, arriving in many cases to maxim of possible regulation.
This consisted on the development of a control system, prepared in the RTU, and a PLC linked to the system SCADA that allows the interaction of the reconection system of the lines of 33kV with the voltage regulators.

Happened a fault transitory in the feeding lines to the E.T. Cañadita and E.T. Los Berros (Figure Nº 1), the opening of the switch of the feeder takes place. When the situation of lack of tension is presented in the bars of 33 kV of ET Cañadita or ET Los Berros, the RTU sends an opening sign at the switches of 33 kV and 13,2 kV of exit of feeders. Lapsed the 5 seconds of time out, the reclose of the failed line is made energizing the power stations again, but in this case in hole.

The setting in service of the E.T. in hole, it allows to isolate the users and to avoid the propagation from the wave of tension to the connected equipment to the network. Lapsed 25 seconds from the re-energization, you proceeds to close the switches of 33 kV (transformer and feeder), giving place to that the regulators of 33 kV carries out an adjustment quick tendency to normalize the voltage to the adjustment value. After this period, is slowed 80 seconds the closing of the switch of 13,2 kV of the transformer. This has as objective to allow that the regulators of 13,2 kV and 33 kV adjust their points of TAP to reach the adjustment voltage.

Because in ET Cañadita, the switch of 13,2 kV is up to the regulators, it is not necessary the opening of the same one, since the regulators of 13,2 kV won’t be able to regulate the voltage if it is not energized.

It is necessary to highlight that in the instant that the 25 second initials are completed, when closing the switches of 33 kV a fall of tension takes place due to the entrance of the load of ET Cañadita, feeder Carbometal and the transformer of ET Los Berros, this situation attenuates the surge that could be generated in the regulators and transformers of both power stations.

The times of wait were determined through the simulation of the operation of the regulators in function of the levels of voltage in permanent state that they are had in the power stations after a loss of a total load.

2.5. Conclusions

The implemented system allows to minimize the effect of the overvoltage that take place in the recloses, avoiding the propagation from these to the connected users.

This operation logic presents benefits and inconveniences which we specify them next:

**Benefits**
- They are minimized the effect of the problems of overvoltage in the users of the network.
- Restitution of the service to the users with the appropriate levels of voltage, protecting their facilities.
- The system acts in totally automatic form, without the intervention of the operator of the system.
- If the operator detects some anomaly (surge in bars, fault of devices, alarms, etc.), he has the possibility to take the manual control and to make the pertinent actions (switch closing, to normalize configurations, etc.).

**Inconveniences**
- Increase of the time outside of service to the users.
- The solicitation of the overvoltage is absorbed by the power stations.

2.7. References