INVESTMENTS IN ELECTRIC NETWORKS: FIVE KEY-FACTORS TO REACH PLANNING EFFICIENCY

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SUMMARY

For EDENOR, the Distribution and Supply Company of northern Buenos Aires (2.2 million customers) there are two main reasons to make planning efficiency a necessity. First, the regulatory scheme for argentine utilities makes the economic profit of the company very dependent on the level of investments. Secondly, the strong energy growth demand (5% per year since the privatisation of September 1992) makes network expansion indispensable. A five action program has been implemented in order to improve planning efficiency which has given good results.

THE REGULATORY SCHEME FOR ARGENTINE UTILITIES MAKES THE INVESTMENT A KEY PARAMETER FOR THEIR PERFORMANCE

The first part of this report presents the main components of EDENOR's concession model: lack of direct control on investment with indirect incentives for the distributor to invest. Inputs for the utility are a regulated pricing scheme (top tariff applicable to the customers) remunerating its distribution costs (in $/kW) more particularly its capital expenditure, and a system of compensations paid to each customer where standards of quality of supply are not met (frequency and time of interruptions, level of tension).

Edenor's Tariff structure and the "Pass Through" of the generation and transmission costs.

The tariff structure applied by the argentine utilities to their customers is built to clearly separate the distribution and supply costs from the generation and transmission costs. The distribution and supply costs correspond with the utility's remuneration. These costs ($/kW), determined at the opening of the privatisation, are fixed for a ten year period. The generation and transmission costs are added to the customer tariff by a "pass-through" mechanism. Both costs follow the fluctuation of prices on the national generation market.

With this tariff structure, reducing operating costs and adjusting investment policies, the utility is able to increase its performance. A compensation system guaranteeing a minimum level of investment and efficiency in the operation has been added to the regulating scheme.

The final cost of supply for a customer could be written:

$$\text{Tariff} = E + DC - B$$

E is the cost of energy and power bought by Edenor on the generation market (generation and transmission costs). To be consistent with the fluctuations of costs on the market, these costs are adjusted each trimester for the customers.

DC corresponds to the costs of Distribution and Supply. It remunerates four items: depreciation of assets, operation and maintenance, supply costs and a business retribution for the owners of the utility.

B corresponds to the compensations paid by the Utility to the customer when standards of quality of supply have not been met.

Edenor's compensation system for poor quality of supply.

This system of compensations given to the customers for poor quality of supply is based on the number and the time of interruptions each customer has experienced in a semester period, and on the portion of time supplied with tension out of standards. When this number or these times have exceeded the standard considered acceptable in the Contract of Concession, compensation is given to the client. This reimbursement is proportional to the unserved energy during the time exceeding the acceptable limits, and to energy served out of standards of tension. Figure 1 shows - for each type of customer - the areas (time-frequency of interruptions) inside of which interruptions are considered acceptable and are not compensated.

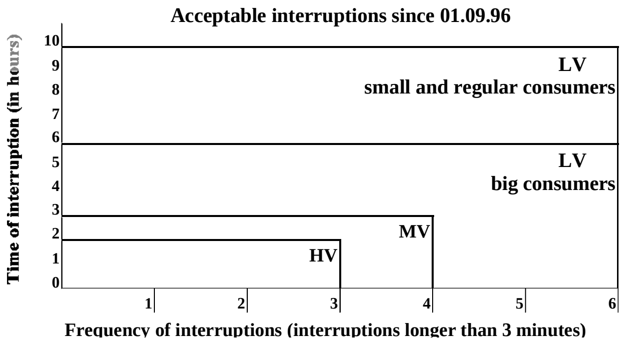

Figure 1: Standards of quality of supply

Figure 2 shows an example of how the compensation is computed for a MV customer. No compensation is paid if both, interruptions are less than four times a semester and each of them is lower than three hours. If one of the interruptions has exceeded three hours, a compensation is paid for the unserved energy corresponding to the time lost exceeding three hours at a cost of 2,71 $/kWh. The unserved energy during the fifth interruption and those proceeding are integrally paid back to the customer at the previous cost. Interruptions shorter than three minutes are not computed.

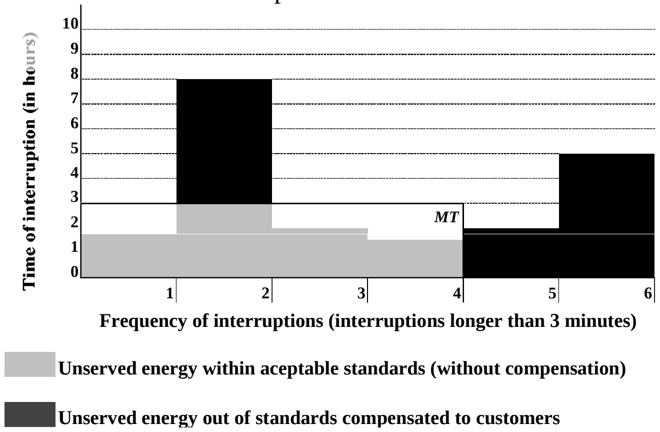

Figure 2: Standards for a MV customer

The implementation of such a system has required a strong effort in developing appropriate software able to compute individual compensation associated with each customer. It is based on a database linking each customer to an element of the electrical network. With each supply interruption detected in Edenor’s Control Centre, it is then possible to determine exactly which customers are without supply and the time lost for each of them in case of a step by step restoration. The individual compensation is calculated systematically for each customer at the end of the semester.

The control of quality of product (level of tension) is not as systematic as is that of quality of supply (interruption). It is based on a rotating survey of sampled customers (about 400 customers are monitored each month, each one for at least a weeks period). At the moment, compensations are paid only to the monitored customers where tension is out of range more than 3% of the time. According to a recent proposition to change regulations, these compensations will be extended first, to all customers beyond those which had been monitored and had tensions lower than standard, and secondly to all customers before those monitored where tensions were higher than standard.

Until now, the compensations paid by Edenor for poor quality of product (several hundred thousand of $ per year) were of low significance compared to the compensations paid for poor quality of supply (several million of $ per year). With the expected change of regulation for Quality of Product, the corresponding reimbursements could be balanced to an amount similar to Quality of Supply.

Edenor’s investment policy derived from regulation.

The National Office of Regulation (ENRE) is in charge of controlling the compliance of Edenor’s Contract of Concession. Edenor’s concession model is characterised by a lack of direct control on investment. The Utility is free to determine the best level of investment, guided by the two series of incentives previously described: tariff income and compensation.

There is no specific term in the tariff formula to remunerate a new investment. It should have to be justified by market growth and the corresponding additional tariff incomes, or by cost reductions (operation costs or compensations). This being for Edenor the major part needed to meet the growth demand (peak growth demand from September 92 to September 98: 5% per year).

As tariff incomes remunerating distribution and supply costs are based on fixed parameters (in $/kW) for a ten year period, every reduction of operating costs or compensations increase the company’s utilities. In a similar way, the additional tariff incomes corresponding to the growth demand enables the utilities to increases as long as the demand can be met from the existing network. On the contrary, when the demand cannot be met from the existing network, these additional incomes are needed to finance the investments required to expand the network capacity.

This shows that the economic profit of the company could significantly be improved by a selective investment policy aimed at reducing operating costs, optimising the use of the existing network capacity and reducing the investments required for expanding the network capacity.

Nevertheless, such an investment policy needs to be compatible with the requirements of the Contract of Concession. If the company is restricting too much of the investments required for expanding the network capacity it will lead to a very high load for the existing network, generating frequent supply interruptions. With the lack of operating reserve to transfer demand from a feeder or a HV/MV substation to another, a minor incident could cause interruptions of large duration. There is a point where the high compensation costs for the company are greater than the gains of postponing investments. A similar limitation exists for the asset replacement policy.

The postponement of asset replacement allows the company to keep receiving tariff incomes for depreciation of assets even when their financial life is overstepped. These incomes generate net utilities for the company as long as the loss of reliability of the assets do not increase the operating costs and compensations. When the compensations and additional operating costs are equal or higher than the incomes for depreciation, it is cheaper for the company to invest in asset replacement.

According to this regulating scheme the purpose of investment planning for a company such as Edenor should be to reach the level of equivalency where it is indifferent for the company investing, or having high operating costs and paying compensations. At Edenor marketing considerations are moving on this economic optimum in a way of more investment and better quality of supply for three main reasons.

Supply interruptions have, now in 1999, a very poor social and political acceptance (especially those of large magnitude or duration) even when inside the standards of quality required by the Contract of Concession. A similar trend can be observed on an individual level. Most of the customers are now requiring a higher quality of supply than the standard. It is particularly true for big industrial and commercial consumers for which supply interruptions mean high losses of production or sales. There is also the additional risks of having them installing autogeneration or gas-based processes when substitution is available. The final reason for Edenor to invest more in expanding the network capacity, is the difficulties of connecting new big consumers within an acceptable timeframe. To keep the area of concession attractive for new big consumers, Edenor needs to have remaining capacity on its networks, especially in the areas of rapid industrial and commercial growth. For example, in the northern part of the concession area and the surrounding territories of the Pan-American Highway, there is a growth demand of about 15%.

FIVE KEY-FACTORS TO REACH PLANNING EFFICIENCY

This second part details the five action programs implemented to improve planning efficiency at Edenor since the privatisation:

1) Centralised organisation for HV/MV planning.

2) Extensive use of cost/benefit analysis to evaluate investment profitability.

3) Equipment standardisation and purchase centralisation, which reduces the per unit costs of equipment.

4) Medium and long-term study of network expansion and structure standardisation, enabling the selection of the less expensive schemes of development for the network.

5) Use of computer tools of last generation (HV and MV network planning, LV and MV mapping system).

Centralised organisation for HV/MV Planning

Considering network planning as a strategic process for the company, it was decided very soon after the privatisation to centralise the HV/MV planning. The Planning Team of eight engineers is in control of the planning for 1.000 km of 220 and 132 kV circuits, 60 LV/MV substations, 800 MV feeders.

The planning process is lead by the Planning Team and includes in-depth coordination with various areas of the company. A brief description of planning activities and responsibilities are presented hereafter. The Planning Team is in charge of forecasting demand and of network constraint detecting. The team prepares a tentative investment program which is then discussed with the operating areas (in 1998: a Transmission Area and 4 Distribution Areas). The field factibility and cost estimation of the projects are elaborated by the operating areas which then are given charge of the project's implementation. The Planning Team is also in charge of estimating the profitability of each project and of synthesising the investment plan. In addition to the HV and MV investments, this plan includes the expected cost for connecting new customers and LV network expansions as well as various other investment projects (hardware, software, buildings...). The new customer connections and LV network expansions are worked out by the Distribution Areas and revised by the Planning Team.

As the sum of all projects which have good profitability generally exceeds the financial capacity of the company, another important step of planning activities is working out an investment plan corresponding to the financial possibilities. According to the priorities given by the CEO and the vice CEO, the Planning Team is in charge of selecting the projects to be implemented in the years to come.

The main benefit of a centralised planning team is its function of synthesization: global view over HV and MV problems (without the traditional antagonism between Transmission and Distribution Areas), and a guarantee for good distribution of limited financial resources. Furthermore, this kind of centralised organisation enables a relatively small team (8 engineers) using advanced planning tools to carry out all the planning process of a company such as Edenor.

Extensive use of cost/benefit analysis to evaluate investment profitability

At Edenor, it is considered of utmost importance to adjust investments according to inputs of the regulating scheme of the company [1]. For this reason the evaluation of profitability for new projects is a basic requirement for the investment decision.

The cost/benefit analysis uses the same parameters in describing the economic model of the company (tariff incomes, saving in operation costs and compensations). Costs include the investment cost of new projects and annual operating costs associated. Benefits include the tariff incomes corresponding to the growth demand which is supplied by the new equipment when the project increases network capacity. The other components computed in the benefits are technical and nontechnical losses saving, penalty saving when the project permits the compliance of standards of quality and operating cost saving. Most of the operating cost savings are due to improvements in operation and maintenance (for example when old assets of high O&M costs are replaced), reduction of the charges for excess of reactive demand at interconnection nodes with the national 500 kV grid and reduction in generation overcosts (when a new project reduces the local generation needed by Edenor for network requirements at its own cost).

Based on these inputs, the profitability of each investment is calculated by classic criteria such as internal rate of return, pay-back and annual net value.

Equipment standardisation and purchase centralisation

The equipment standardisation and purchase centralisation aims at reducing unit costs of installations. Centralised teams for both activities were created in the beginning of the privatisation.

The standardisation of Edenor's equipment is based on a rigorous cost/benefit comparison of alternatives complying with the technical requirements.

The centralisation of purchases enables Edenor to receive better prices for goods and materials and too order larger series, optimising stocks and reducing costs of purchasing.

Equipment costs have been reduced to about 20% since the privatisation, partly due to the above actions, partly to the trend of unit price reduction observed on the international market of electric equipment during the last years.

The manpower costs for erection, assembling and other services have also been significantly reduced (about 10% since the privatisation). Edenor is constantly updating a set of reference costs for all the basic services which are normally subcontracted. It allows the bidders to price the best offer compared to the reference list, enabling transparency in bidding and avoiding speculations.

Medium and Long term study of network expansion and structure standardisation

The study and optimisation of medium and long-term network expansion enables Edenor to select the cheapest schemes for development of the network and the most adequate standards for equipment (voltage level, transformer sizes, substation design...).

At Edenor, the planning process is divided into three cycles:

The long term planning (10-25 years) identifies long term trends and changes in network expansion philosophy (voltage level, transformer sizes, substation design...).This plan is updated with a periodicity of 4/5 years.

The mid term planning (5 years) determines investment requirements and capital expenditure. A first balance with the expected financial resources of the company is calculated and the mid term investment plan is adjusted to the financial possibilities. This plan is updated yearly.

The annual planning selects among the projects suggested in the mid-term planning, those which would then be implemented the following year.

The investment planning methodology includes four steps:

A market survey able to estimate the future growth demand.

A technical analysis to determine investment requirements: power flow simulations detecting the installations that would overload and the selection of equipment characterised by a poor level of reliability or high operating costs for possible replacement.

A cost/benefit analysis first determines the best solutions among several alternatives for eliminating overloaded and unreliable elements of the network. Then it evaluates the profitability of each recommended investment.

The investment plan design prioritises the recommended investments according to their profitability and the financial possibilities of the company.

Use of computer tools of next generation

Since the privatisation Edenor has continuously modernised its planning process by introducing computer tools of next generation, for power flow studies as well as for database management.

For its transmission system power flow studies, Edenor uses the PSS/E® software from PTI which is a de facto standard for the companies concerned by the argentine's transmission system. The main benefit for using the same software as other argentine companies is the easy transfer of data and study results.

For its MV system, Edenor's Planning Team uses the BASIX®/PRAO® software from EDF [2]. PRAO® is a comprehensive decision-aid software model that enables the user to know the electrical state of the network and too develop it. It is based on an interactive graphic system and also includes advanced functions optimising the operating scheme. The program also works out development strategies and analyses the return of investment and the quality of supply. Due to the size of its network (about 800 MV feeders) Edenor uses BASIX®, a reference database as a data server for PRAO®.

Various other computerised databases have been implemented. The first is a mapping system describing the LV and MV network on a typographic scheme. It was implemented by the operating areas to give them a reliable description of the LV network for the monitoring of quality of supply. An on-line MV database for the new MV Control Centre has also been implemented.

The next step for modernising data management at Edenor will be to implement a graphic interface system (GIS) able to unify the description of the whole network (from the HV to LV). It will guarantee the synthesization of information, avoiding data duplication and providing each application with the specific information it needs (planning studies, Control Centre, quality of supply...).

THE RESULTS

The improvement of planning efficiency at Edenor has given good results. Since the privatisation, EDENOR's HV/MV substations and MV feeders load peak factors have been significantly increased while penalties for quality of supply have been maintained within acceptable levels.

The system planning has aimed at eliminating the bottlenecks of the network making as good use as possible of the existing capacity and postponing the construction of new substations. The good estimation of the emergency capacities available from one substation to another associated with the standardisation of a MV network design, are the actions which have enabled Edenor to make a major use of the existing systems [3]. During the last five years, the number of overloaded MV feeders and substations has been drastically reduced while their load factor has considerably increased. Theses results have been reached by the computerisation of the MV network state estimation and planning, as well as the improvement of the load data collection for MV feeders.

MV network load

The following figures show the results of the first five years of system planning at Edenor, illustrating the evolution of the average peak load factor since the privatisation.

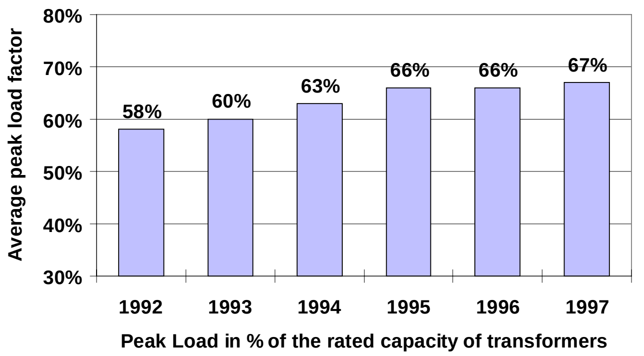

Figure 3: HV/MV substations average peak load factor

A major use of the capacity has been reached for HV/MV substations (Figure 3). The factors that allowed Edenor to reach this goal were: the availability of more precise information on the existing loads of MV feeders, better operating schemes (optimising the normally open point on the MV loops) and better estimation of emergency capacities available from one substation to another. Nevertheless, it should be noted that the average peak load level observed during the last two years was exceptionally high and partly due to delays in the commissioning of new substations (environmental constrains). In the coming years, this average load is expected to slightly decrease.

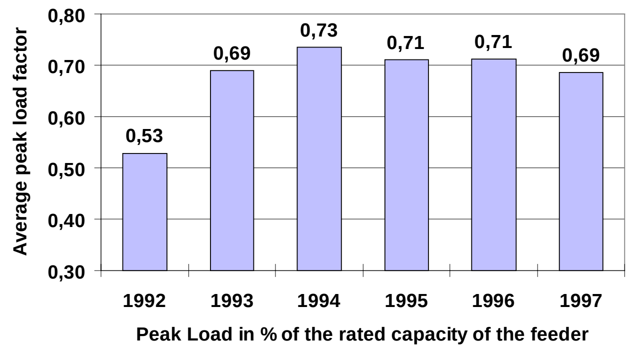

Figure 4: MV feeders average peak load factor

The average peak load factor for MV feeders has also been increased since the privatisation (Figure 4), though there was a slight decrease from year 94 to present.

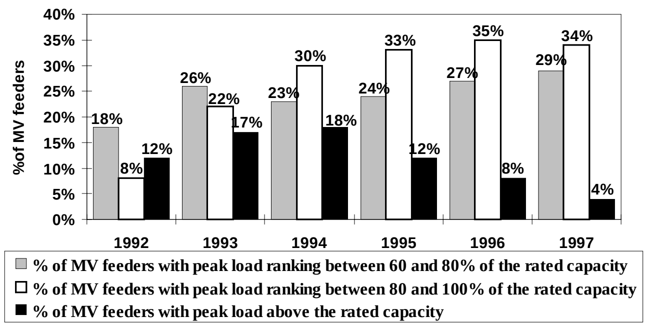

Figure 5: % of high loaded MV feeders

One of the most important results of the efficient planning focused on eliminating the bottlenecks of the network, is the important reduction of the percentage of overloaded feeders (4% in 97 instead of 17/18% in 93/94) as shown in Figure 5.

Quality of supply

Despite of the significant increase of the average peak load factors for EDENOR's HV/MV substations and MV feeders, penalties for quality of supply out of standards have drastically been reduced during the first years of the concession and then maintained within acceptable levels.

Figures 6 and 7 show the evolution since the privatisation of two indicators measuring the level of the quality of supply (annual average frequency and time of interruption for a KVA of installed capacity in MV/LV substations).

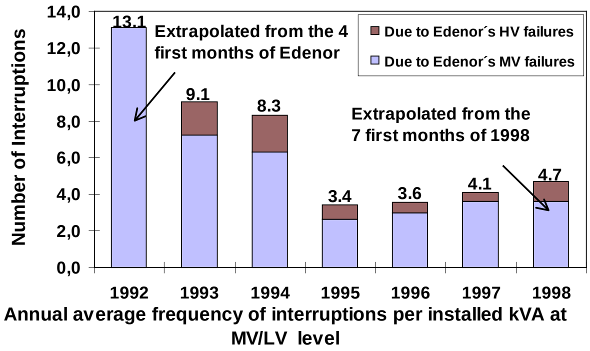

Figure 6: frequency of interruption per kVA since the privatisation

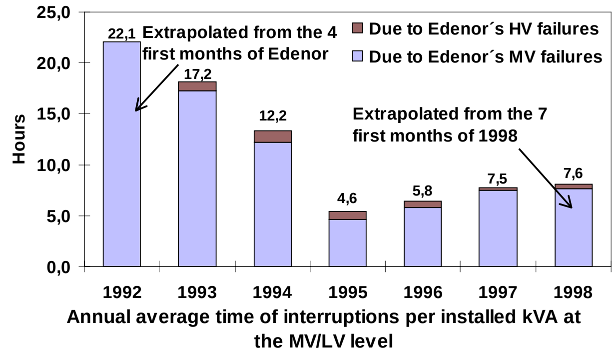

Figure 7: Time lost per kVA since the privatisation

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