RELATIONSHIP BETWEEN THE RELIABILITY OF SUPPLY TO END USERS AND THE RELIABILITY OF THE BULK ELECTRICITY SYSTEM (BES) - REGULATIONS AND EXPERIENCES GAINED WITHIN THE MODEL ADOPTED BY THE REPUBLIC OF ARGENTINA

M. V. González Sábato - O. Ramati - A. Caro
ADEERA (Argentina)
Tacuarí 163,8º Piso- (1071) Buenos Aires - Argentina
Tel: 54 1 334 0401 - Fax: 54 1 343 9205 - E-mail: adeera@ciudad.com.ar

SUMMARY

The introduction puts forward that an important aim of the paper is to show that the Quality Model applied to Generation, Transmission and Distribution as a whole in Argentina is not homogeneous and therefore does not produce the expected results. There follow a brief description of the regulatory framework governing the sector's activities and the detection of simplified concepts which give rise to the inconsistencies of the model concerned, as well as of its actual effects. At the end, the paper proposes an alternative quality model, deemed to be a solution to the Quality problems, in terms of Adequacy and Security, presented by the BES to the Distribution companies.

1. INTRODUCTION

The organizational changes occurred in the electric sector in the majority of the countries around the world have modified many technical, economic and legal approaches in relation to such sector. This is specially true when it comes to Service Quality, which has gradually been deemed to be no longer related to the end users only and is now analyzed in terms of different stages of electric power production and transmission, besides the typical study carried out for distribution.

Rarely is the expression "service quality" found in the traditional bibliography referred to large generation and transmission networks. Whereas "reliability", as far as "adequacy" and "security" are concerned, appears very frequently [1-2]. It could be said that this is merely a question of usage of terminology, since reliability is one aspect of quality; nevertheless, the experience gained in Argentina shows that this is an essential issue. As a matter of fact, service quality to end users implies a rigorous numeric evaluation and, in the Argentine model, as in the case in the model used in many other countries, the implementation of a strict fine system to companies providing the service when the pre-established targets are not met. Instead, reliability analyses of large generation and transmission networks, in terms of adequacy and security, have primarily had to do with the planning of those systems [1-2].

The re-structuring which took place when passing from companies vertically integrated to companies with vertical separation of activities (generation, transmission and distribution entities are separated) implies a similar treatment as to service quality issues in the different stages. Today we can refer to "transmission systems users" or, to be less specific, to "bulk electric system users". Quality levels at each nodes linking transmission and distribution networks are spread to end users and distribution companies have to be able to act so that the quality received from the respective interconnected production and transmission system is compatible with the quality demands imposed to themselves by the regulation.

The possibility to act in this sense, on the part of distribution companies, depends indeed on the regulatory framework, but in any case it is essential to count on clear and objective evaluation methods which allow for numeric comparisons in the different stages.

When, besides the vertical separation of activities, the electric sector organization determines that the transmission network expansion is to be subject to "market decisions", as is in the Argentine case, quality numeric evaluation at strategic points becomes even more important, taking into account that the market operates by means of "signals" and that the signals referred to quality constitute, together with energy and power price signals, the most important matter in terms of overall operation. Then we should talk about "quality cost" and, therefore, cost and quality concepts would remain inseparable.

This paper aims at showing that the quality model applied in Argentina to power generation, transmission and distribution systems as a whole is not homogeneous, and thus, the solutions required by the regulation itself for end users are not found. It also includes an alternative model capable of solving quality matters without leaving aside the essential aspects of the general regulatory framework.

For the paper to be understood by those who are unaware of the current organization of the electric sector in Argentina, at the beginning there is a brief description of the regulatory framework applied. The terminology used also aims at making such terms as "quality", "adequacy" and "security" easier to be understood, when applied in the generation, transmission and distribution stages.

2. REGULATORY FRAMEWORK IN ARGENTINA

As from 1991, the Argentine electric sector was deeply transformed, when passing from companies which were mostly state-owned at national or provincial level and which were vertically integrated, to companies which mostly belong currently to the private sector, working under a system of vertical separation of activities. The most outstanding features of the regulation governing the activity today are [3]:

- Generation is a risk activity subject to market rules, although it is dispatched with an overall economic criterion according to costs of production and transmission.
- Generation companies are not fined for scheduled or unexpected out-of-service conditions of their machines.
- Transmission is a public service granted in concession by the Nation State.
- Transmission companies (Transmitters) are fined for outage state of their network components, according to a ranking of importance and proportionally to the time they remain out of service. These fines are independent of the effects produced by the outage conditions on distribution networks.
- Transmitters are compensated with fixed values for the number of connection points to distribution networks, to generation facilities and to Great Users facilities directly linked to them. They are also compensated with fixed values for their network transmission capacity and with variable values for the energy transmitted.
- Distribution is a public service granted in concession. Three of the distribution companies (EDENOR, EDESUR and EDELAP), which as a whole distribute around 45% of the country's total electric energy, have entered into concession agreements with the Nation State. There are also fourteen private companies that have entered into concession agreements with the Provinces and ten companies that remain owened by Provincial states.
- Private distribution companie are compensated for the supply to their clients by means of regulated tariffs, in which the energy and power wholesale cost is shifted by means of a "pass-through" mechanism. These characteristics in some case differ depending on the State granting the concession. For distribution companies owened by Provincial states tariff is established directly by the government.
- Distribution companies (Distributors) are fined for interruptions in the supply to consumers, in proportion to the number of interruptions and to their duration, whether originated at their networks or at the Bulk Electricity System (BES).
- Great Users are those entering into supply agreements directly with Generation companies or with Dealers (acting as intermediaries between Great Users and Generation companies). To that end, they have to pay a toll to Transmitters and to Distributors, if they are connected to their networks. This toll is regulated.
- There are three categories of Great Users (GU): Great Major Users (over 1 Mw); Great Minor Users (over 100 Kw) and Great Private Users (over 50 Kw). The service rendered by Distributors and the toll the Great Users have to pay as compensation depend on the category.
- Distributors may be able to supply the electric energy intended for their own clients through a Spot Market (with a mechanism of Seasonal Prices and Compensation Fund), and/or by means of contracts with Generation companies in the so-called Forward Market. For the "pass-through" of the wholesale energy, the Spot Market seasonal cost is taken into account.
- The BES operation is under the charge of an Independent Operator, CAMMESA, which is also in charge of managing the market economic transactions.
- Transmitters are not allowed to invest in their network expansion and the compensation received does not include expansion costs.
- Transmission network expansions are carried out on the initiative of and due to the interest of their users (Distributors, Generation companies and GU), through three different mechanisms: Public Bidding, Contract Between Parties and Minor Extension.
- The expansion initiative by a transmission network user must be backed by at least 30% of the so called "expansion beneficiaries" for the relevant works to be authorized by the National Electric Regulation Entity (ENRE) and to be carried out by means of a Bidding. In that case, expansions will be paid by the whole "beneficiaries".
- Expansions works may be carried out by the Transmitter involved or by a so-called Independent Transmitter (TI). In the latter case, the TI will carry out the expansion operation and maintenance, under the Transmitter's supervision.
- Alternatively, a transmission network user may enter into a Contract Between Parties with a Transmitter or with a TI and afford an expansion, which is also to be authorized by the ENRE. Nevertheless, free access to the expansion cannot be prohibited, as long as the remaining capacity is enough.
- Minor Extensions are proposed by the respective Transmitter, authorized by the ENRE and paid by all "beneficiaries".
- An expansion "beneficiary" is exclusively determined by his possibility to use it physically.
- Transmitters make an indicative network planning, by means of Reference Guides, with prospective data contributed by the Nation State. Options arising out of these Guides aim to orienting investors, but the works that may arise are not compulsory.

3. DEFINITIONS

A close analysis of point 2 will lead to two outstanding matters that are essential in the Quality Model adopted: a)Distributors are fined for interruptions in the supply to their clients as a result of facts occurred at the BES; b) Distributors, as supposed "beneficiaries", may foster transmission expansions if they pay them in proportion to the "benefits". Regulatory authorities explain that that leads Distribution companies to make investments to solve Quality problems resulting from transmission networks.

That concept on the part of regulatory authorities is based on an unsuitable simplification of the idea of Service Quality and its results is the non solution of problems, as can be seen further on. In order to understand the meaning of this simplification, we are including here a series of definitions adopted by us in relation to the service and the product delivered by the BES to the Distribution companies. Those definitions are based on publication by CIGRE and the WSCC [2, 4].

Quality: the composition of such concepts as product quality (Frequency Quality and Voltage Quality) and Reliability.
Reliability: the combination of Adequacy, Security and Integrity, as defined as follow.
Adequacy: system ability to satisfy users´s power and energy joint demands, within the component ratings and voltage limits, taking into account planned and unplanned reasonably expected outages of system components, as well as the preservation of Security.
Security: the system ability to withstand specified sudden disturbances such as electric short circuits and/or unexpected outages of system components.
Integrity: system ability to preserve its interconnected operation and to avoid an uncontrolled separation in case of severe disturbances.

Some necessary comments concerning the foregoing definitions will serve our purpose.

CIGRE refers to such concepts as Adequacy and Security respectively as Static Reliability and Dynamic Reliability. The idea of Adequacy should be associated with the prolonged availability or unavailability of means of production and/or transmission. For instance, the supply interruptions occurred in Argentina during the summer of 1988, due to very low hydraulic levels in all catchment basin areas and high unavailability of thermoelectric machines. Another example of very low Adequacy, in this case stemmed from transmission system, took place when a hurricane caused the fall of two power lines in an important link corridor between a hydraulic generating area and power consumption areas.

By contrast, Security is affected by unexpected disturbances that, though not implying a prolonged outage of system components, produce a supply interruption. For instance, a relaying protection system not acting selectively may make a simple fault in a transmission line result in supply interruption in one or several nodes linking the transmission system with distribution networks.

It is also worth mentioning that when CIGRE determined the object of the bulk electrical system planning, design and operation it stated that: "the system security should be preserved in such a way that recovery from more probable contingencies can be achieved without load curtailment or interruption and avoiding excessive stress on the system and its components". It should then be understood that for the system to be Secure it should be capable of managing reasonably possible contingencies without any load curtailment or interruption. Therefore, it is obvious that the sudden outage of a single component of the transmission network or a generating machine, with the network operating previously in a normal condition, should not bring about supply interruption.

4. SIMPLIFIED CONCEPTS THAT LEAD TO INCONSISTENCIES IN THE QUALITY MODEL

The first simplified concept that should be noticed in the Argentine quality model is directly related to the definitions mentioned in the preceding point.

As a matter of fact, solutions to Adequacy problems are absolutely different from solutions to Security problems. Generation Adequacy is a problem of the market and supply contracts between Distributors and Generation Companies could facilitate the erection of new generation plants, while Distributors could assure its supply for reasonable prices. Transmission Adequacy could admit solutions like the one supported by regulatory authorities, with investments by Distributors and by other users of the Transmission Systems so as to avoid the lack of power due the scarcity of networks. But, in most cases, problems affecting Security really do not fall within the scope of solutions contributed by Distributors.

In fact, such solutions generally do not involve transmission network expansions. The point is either to improve the protection and control systems or to adopt appropriate operating criteria.

In short, we may say that this simplified concept consists in NOT APPROPRIATELY DIFFERENTIATING ADEQUACY PROBLEMS FROM SECURITY PROBLEMS, as Quality components.

The second simplified concept we should take into account is referred to the determination of a Energy Not Supplied fixed price and from which the ENS costs stem. That way

these costs depend only on the duration of the supply interruptions and not on the frequency of them. For instance, based on that criterion, a half-hour interruption in a network sector implies the same ENS cost as six five-minute interruptions in the same network sector. According to this criterion and to the ENS price now in force, it would be very difficult to justify investments with a view to solving current Security problems in the transmission network.

In short, this simplified concept consists in NOT DIFFERENTIATING COSTS PER TIME UNIT OF "ENS" ARISEN OUT OF A SERIES OF SHORT-TERM PROBLEMS, RELATED TO SECURITY, FROM A SINGLE LONG-TERM PROBLEM RELATED TO ADEQUACY.

A third simplified concept is related to the transmission network operation criterion and to the simplification described above. This criterion is based only on an economic aspect and admits that the outage condition of a single network component may give rise to supply interruptions, though the problem may have been caused by a reasonably probable contingency, provided that the ENS cost be lower than the reduction in energy costs produced by operating the network in this way. According to this criterion, in Argentina the sudden outage of any line of two important corridors due to a fault may, under certain load conditions, lead to supply interruptions through the action of disconnecting generation devices to avoid the loss of stability, followed by load disconnection using frequency relays.

This simplified concept consists in APPLYING TO THE LETTER AN OPERATION CRITERION BASED ON AN ECONOMIC EQUATION, DISREGARDING A CRITERION, ACCEPTED BY DEVELOPED COUNTRIES, THAT SETS FORTH THAT THE SUDDEN OUTAGE OF A SINGLE COMPONENT OF THE TRANSMISSION NETWORK SHOULD NOT BRING ABOUT LOAD INTERRUPTIONS, AT LEAST WHEN THE NETWORK WAS OPERATING UNDER NORMAL WORKING CONDITIONS.

The problem described for the transmission network applies to generation system, when admitting the incorporation of units of such high relative power that its unexpected outage brings about load interruptions due to load shedding by frequency relay operation.

Finally, we will mention a quality problem arising from the application of the model as if the electricity companies were vertically integrated and the only users to be taking into account were the end users.

While Distributors are fined for supply interruptions affecting each one of its clients, including supply interruptions originated at the BES, Transmitters are fined for the outage state of their networks components, whatever the effect such condition may bring about. Moreover, the proceeds from fines imposed on Distributors are returned, through discounts on invoices, to end users themselves, whereas proceeds from fines imposed on Transmitters are not returned to users of their networks.

It is undoubtedly a NON HOMOGENEOUS QUALITY MODEL, which gives rise to an interesting paradox in the Republic of Argentine : though the Transmission companies have increased their efficiency and reduced the number of unexpected outages of their network components , the interruptions in nodes linking with Distributors networks and the interruptions caused by load shedding have increased. This is due to the increased use of transmission systems, which work very close of their operating limits.

5. EFFECTS OF QUALITY MODEL INCONSISTENCIES

5.1. Effects on the Current Security Level

The characteristics of fines imposed on Transmitters, the lack of definition as to the responsibility of investments to be made so as to adjust protection and control systems to increased demands required from transmission systems, the operating criterion based on ENS costs and the little effectiveness of the disturbances occurred diagnoses, due the lack of an analysis methodology duly conformed to the sector current organization, had resulted in maintaining for the last five years a high number of contingencies in the transmission networks which caused supply interruptions. In Table 1, the annual average number of disturbances in terms of interruption Severity is shown. Said Table shows only interruptions caused by 500 Kv network problems and interruptions affecting all regions of the country. Local disturbances, due to 132 Kv networks problems and failures in 500 Kv radial lines that supply power-importing regions are excluded.

Table 1 - Annual Average of the Number of the BES disturbances as per Severity

SEVERITY (Syst-Min)	DISTURBANCES/YEAR
1 to 2	1.8
2 to 3	1.0
3 to 4	0.6
4 to 5	1.0
5 to 6	0.4
6 to 7	0.6
7 to 8	0.6
8 to 9	0.4
9 to 10	0.2
10 to 11	0.2

The Severity index has been chosen since most of the effects on the loads are produced by the load shedding operation, with very few nodes linking with distribution networks showing effective disconnection. There, it may be observed that the disturbances with Degree 1 impact (between 1 and 9 System Minutes) are approximately 7 per year. It represents a significantly high figure *vis a vis* international standards. Statistics cover the 1993-1997 period and a more detailed analysis than the one shown in the table would confirm that the number of Degree 1 Severity disturbances have not decreased at the end of the five-year period.

In order to compare someway the sudden supply interruptions originated in the BES that affected the users of the distribution networks with the sudden supply interruptions originated in the very MV distribution networks, we selected the Frequency of Interruptions per KVA Installed index (FMIK). Though this index does not permit a direct comparison with the results presented for the BES, it may be useful as a reference and we employ it because there are significant complete data for the First Stage of Quality in the Electric Energy Distribution (1993-1996), for the two greatest distribution companies of the country [5]. These two companies were also the first privatized ones and therefore it is possible to see the evolution of the service quality.

Table 2 - Frequency of Interruptions per KVA Installed Index (FMIK)- Internal Origin - Period 1993-1996

INTERNAL FAULTS		FMIK INDEX
Company: EDENOR S.A	Semester 1	4.048
	Semester 2	4.015
	Semester 3	1.665
	Semester 4	1.549
	Semester 5	1.921
	Semester 6	1.338
Company: EDESUR S.A.	Semester 1	2.861
	Semester 2	2.236
	Semester 3	1.491
	Semester 4	1.099
	Semester 5	1.292
	Semester 6	1.316

We can observe that to the end of 1996 each client of these two companies had an average rate of sudden supply interruptions originated in the MV distribution networks of approximately 2.6 per year.

It is possible to say that, even reaching a practical optimal rotation of the frequency relays operation, the number of sudden supply interruptions per client originated in the BES (considering only Degree 1 contingencies) should be similar to that originated in the MV distribution networks.

5.2. Future Effects on Adequacy and Security

Though nowadays the 500 Kv and 132 Kv Transmission Adequacy level is not the cause of extended supply interruptions, except in accidental cases, it has been recognized that the network expansion methodology has not achieved until now the results expected by the people who designed the regulatory framework. This is due to several causes, which are now being duly identified and within which we may now mention the inaccurate assignation of "beneficiaries" and the absence of property rights (implying the potential danger arisen out of free-riding) [6]. As a result of an inadequate regulation during the last five years only a 500 Kv line has been erected, representing 6.7% of the total network, at that voltage level. Said construction was driven by the Nation State since it allows an unrestricted delivery from the still state-owned Yaciretá hydroelectric plant. A fourth 500 Kv link between the major Comahue generating region and consumption centers, technically considered as extremely important, recently reached the required market agreement after several years of negotiation and is under construction process. The 132 Kv network scenario is not better.

If the regulations governing expansions is not amended and the increases demand together with the growth in electrical energy export to Brazil are maintained, transmission network Adequacy problems and growing Security problems due to an increased utilization of existing networks may be expected.

6. ALTERNATIVE QUALITY MODEL

Here we will only describe some basic ideas and recommended seeing Ref. [7] for further details.

Our alternative model was thought considering as little separation as possible from the Argentine regulatory framework, though we recognize that the concession contracts make their enforcement somewhat difficult.

To begin with, the quality model must clearly differentiate Adequacy from Security. In the case of the Adequacy model, we understand that changes in the identification of "beneficiaries" and regulatory amendments suppressing the risks derived from free-riding for investors should be enough to have the required expansions carried out. Under these conditions, the current model, only applied to Adequacy aspect, may continue in force.

Our proposal expressly differentiates the Security aspect : A) though Distributors would go on being fined for the supply interruptions suffered by their customers, including those originated in their networks and those derived from Transmission Security problems, they would receive refund from the Transmitters, if Security problems arise out of their networks. B) Transmitters would be fined in

terms of real effects on distribution networks, using an index that determines the proportion of the supply interruption in each one of the affected nodes (delivery points) in relation to the interruption that would produce a total disconnection of each one of them (this index takes into account a partial load shedding of the total load of the delivery point). Such fine would be the refund to Distributors. C) Distributors would not be fined for Security problems originated in sudden outages of generating machines. D) as to the operation, the following criterion would be adopted: the sudden outage of a single component of the transmission networks would not give rise to supply interruption if the networks were operating under normal conditions before the contingency. E) the addition of new generating machines would not be authorized if their unexpected outage implied supply interruptions.

7. CONCLUSIONS

The vertical separation of generating, transmission and distribution activities forces the responsible staff of the relevant companies to be ettentive to what is going on, regarding both the regulatory and technical aspects, in the stages which are not under their direct responsibility. As a matter of fact, regulatory and technical aspects are indissolubly linked, as shown by the Quality Model research. The adoption of an efficient quality model when carrying out an electrical sector restructuring is essential to achieve a sustained succes, particulary when restructuring foresees that the sector will operate through market decisions, without centralized decisions, with a minimal intervention of the State. We understand that the restructuring of the electricity sector in Argentina was carried out with a general succes and that the errors included in the quality model may be corrected. Nevertheless, such correction will demand a substantially major effort than the one that would have been required had the initial design been correct, due to the fact that the corrections may bring about changes in the “rules of the game” already set forth by concession contracts and by the regulations in general.

8. REFERENCES

[1] W. H. Winter ; B. K. Lereverend ; E. Mariani ; K. Turner,“Power System Performance and Reactive Scheduling”, CIGRE Session , Paper 39-18 , Paris, August - September 1988, pp. 1-5.

[2] CIGRE Working Group 38-03,“Power System Reliability Analysis Application Guide”, Edited by Lesley KELLEY-REGNIER , a CIGRE Publication , Paris, 1987, pp.6-11.

[3] Compañía Administradora del Mercado Mayorista Eléctrico (CAMMESA), “Procedimientos para la Programación de la Operación, el Despacho de Cargas y el Cálculo de Precios”-Versión XI , Buenos Aires , 1997.

[4] Western Systems Coordinating Council (WSCC), “Reliability Criteria for Transmission System Planing”, Part IV - Revised March 11, 1997 ; USA, pp. 1-7.

[5] Secretaría de Energía, “Prospectiva 1998”, Buenos Aires, Argentina, 1998, pp. 214-241.

[6] E. A. Bour - “ La Regulación del Sector Eléctrico en la Argentina (1992/1998)” - Versión Preliminar, Fundación de Investigaciones Económicas Latinoamericanas FIEL - Buenos Aires, Argentina, December 1998, pp. 26-39.

[7] M. V. González Sábato,“Calidad de Servicio del Sistema Eléctrico Mayorista - Aspectos de Suficiencia y Seguridad” - Primera Parte, ADEERA , Buenos Aires, May 1998, pp. 82-86.