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ENERGY DEVELOPMENT AND POWER GENERATING COMMITTEE
International Practices for Energy Development and Power Generation Subcommittee

PANEL SESSION: RISK RESPONSIBILITY FOR SUPPLY IN DEREGULATED ELECTRICITY MARKETS—THE LATIN AMERICAN CASE[#]

IEEE 2003 General Power Meeting, Sheraton Centre Toronto Hotel, Toronto, Canada, Tuesday, July 15, 2003, Sheraton/Conference Room G, 9:00 a.m.

EXTENDED FULL LENGTH PAPERS

Chair: Tom Hammons, Chair, International Practices for Energy Development and Power Generation, University of Glasgow, Scotland, UK
Ivan Marques de Toledo Camargo, ANEEL, Brazil
Hugh Rudnick, Pontificia Universidad Catolica de Chile, Chile

This Panel Session reviewed the supply problems faced in Latin America electricity markets over recent years, and how markets and regulations have worked in relation to allocating the responsibility for supply. The risks associated with that responsibility was discussed together with how different countries have taken actions in this regard, and the consequences of those actions.

In Latin America two approaches have been used to allocate the responsibility on electricity supply.

- The government keeps the final responsibility on the supply. Suppliers (distribution companies or traders) do not have control on the rationing when it becomes necessary to curtail load. In such case, they cannot manage the risks associated to the supply. This is the case in the markets of Brazil and Colombia.

- The responsibility is fully transferred to suppliers. The regulatory entity supervises the quality of the supply and different types of penalties are applied when load is not supplied. This approach permits suppliers to have great control on risks.

The presentations analyzed the performance of both approaches, and conclusions on their effectiveness were given.

Principal contributors included:

1. Ivan Camargo and Dilcemar de Paiva Mendes (Risk Responsibility for Supply in the Brazilian Energy Market)
2. Hugh Rudnick, (Risk Responsibility for Supply in Deregulated Electricity Markets—

[#] This document has been prepared and edited by Hugh Rudnick, Pontificia Universidad Catolica de Chile, Chile, Tom Hammons, Chair, International Practices for Energy Development and Power Generation, University of Glasgow, Scotland, UK, and Ivan Marques de Toledo Camargo, ANEEL, Brazil

The Chilean Case)

3. L. A. Barroso, M. V. Pereira, and J. Rosenblatt (Ensuring Energy Supply Adequacy in Market-Based Systems—The Brazilian Experience)
4. Jorge G. Karacsonyi (Risk Responsibility for Supply in Latin America--The Argentinean Case)
5. Fernando Gomez G. (Electricity Markets—The Latin American Case: The Colombian Case)
6. Marcelino Madrigal and Francisco de Rosenzweig (Present and Future Approaches to Ensure Supply Adequacy in the Mexican Electricity Industry).

Presented were the views of renowned international authorities from Latin America on risk responsibility for electricity supply, adequacy of energy supply, and supply in deregulated electricity markets, from Argentina, Brazil, Chile, Colombia, and Mexico.

Each Panelist spoke for approximately 20 minutes. Each presentation was discussed immediately following the respective presentation. There was a further opportunity for discussion of the presentations following the final presentation.

The Panel Session was organized by Ivan Marques de Toledo Camargo, ANEEL, Brazil; Hugh Rudnick, Pontificia Universidad Catolica de Chile, Chile; and Tom Hammons, Chair of International Practices for Energy Development and Power Generation, University of Glasgow, UK.

It was moderated by Tom Hammons, Ivan Carnargo, and Hugh Rudnick.

The first presentation was entitled 'Risk Responsibility for Supply in the Brazilian Energy Market' and was by Ivan Camargo and Dilcemar de Paiva Mendes, both with the Brazilian Agency for Electricity Regulation, ANEEL.

The presentation contributed to the discussion on the supply problems that have been faced in Latin America electricity markets over recent years, and how markets and regulations have worked in relation to allocating responsibility for supply. It presented remarks on causes and consequences of recent rationing in the Brazilian power system. The presentation also reviewed the actions that were undertaken and issues that are under review to reduce likelihood of shortages in the future, as well as to attribute responsibilities.

Ivan Camargo received his Ph.D. degree from INPG (Grenoble, France) in 1988. Since 1989 he has been a lecturer at Universidade de Brasilia in Brazil.

Dilcemar de Paiva Mendes received his Ph.D. degree from UMIST in 1999. Since 1993 he has been a lecturer at Universidade Federal do Ceara in Brazil.

The second presentation was entitled 'Risk Responsibility for Supply in Deregulated Electricity Markets – the Chilean Case'. It was presented by Hugh Rudnick, Professor of Electrical Engineering, Pontificia Universidad Catolica de Chile, Chile. It reviewed supply problems that have been faced in the Chilean electricity market over recent years, and how market and regulations have worked in relation to allocating responsibility for supply. The risks associated with that responsibility was discussed, as was how Chile has taken actions in this regard. The presentation analyzed performance of the approach that has been adopted, the crisis faced in 1998-1999, and the changes that have been introduced to the regulation due to the crisis.

Hugh Rudnick received the B.Sc. degree from the University of Chile, Santiago, and the M.Sc. and Ph.D. degrees from Victoria University, Manchester, UK. His research

and teaching activities focus on the economic operation, planning, and regulation of electric power systems. He has been a consultant with utilities and regulators in Argentina, Bolivia, Central America, Chile, Colombia, Peru, Venezuela, the United Nations, and the World Bank, mainly on the design of deregulation schemes and transmission and distribution open –access tariffs.

The third presentation was on ensuring adequacy of energy supply in market-based systems: the Brazilian case and was prepared by Luiz Augusto Barroso, Mario V. Pereira, and Jose Rosenblatt. Barroso is a senior analyst and is currently working towards a Ph.D. degree in Optimization at COPPE-Federal University of Rio de Janeiro: Pereira is President of PSR and its associated company; and Rosenblatt is with PSR and its associated company responsible for regulatory and market studies.

This Panel presentation briefly assessed the present stage of the Brazilian power sector reform, and evaluated the 2001 energy crises--its effects and proposals for power sector model improvements. The Brazilian government faces a considerable number of challenges: price signals and operational reliability, and investment and supply security in the long term. In the presentation, the most recent proposals and alternatives for ensuring security of supply in Brazil were evaluated, and alternatives and proposals learned from other countries' experiences were assessed.

Luiz Augusto Barroso has a B.Sc. degree in Mathematics and a M.Sc. degree in Operations Research, both from the Federal University of Rio de Janeiro.

Mario Pereira has a B.Sc. degree in Electrical Engineering from PUC/Rio and M.Sc. and D.Sc. degrees in Systems Engineering (optimization) from COPPE/UFRJ- Research, both from the Federal University of Rio de Janeiro.

Jose Rosenblatt has a B.Sc. degree in Electrical Engineering from PUC/Rio and a M.Sc. degree in Operations Research from Stanford University. He also concluded an Executive M.B.A. for the Power Sector at UFRJ's Economics Institute.

This presentation was given by Luiz Augusto Barroso.

The fourth presentation was made by Jorge G. Karacsonyi, Professor of Comparative Regulation, Instituto Tecnologico de Buenos Aires, formerly President of the Energy Commission of the Centro Argentino de Ingenieros. He discussed risk responsibility for electricity supply in Argentina. Transference of final responsibility of supply to distribution companies seems to be an efficient means to ensure quality of service and expansion of generation. By contrast, previous experiences in Latin America where Government assumes that responsibility have been less satisfactory, and implied high social costs have not always been quantified. This was discussed.

Jorge Karacsonyi obtained his degree in Electromechanical Engineering at Buenos Aires University. More recently, as member of the Mecado Energeticos staff, he was an advisor to public entities and private companies in competitive markets on electricity and gas in twenty two countries. He was team leader for many studies committed to Mercados Energeticos#. These include electricity market design, the calculation of tariffs, economical and risk assessment of generation plants, transmission facilities, pipelines, and so on.

The penultimate presentation was Entitled: 'Electricity Markets—The Latin American Case: The Colombian Case'. It was given by Fermando Gomez G,. Universidad de la Salle, and Escuela Colombiana de Ingenieria, Colombia, where he teaches Power Systems and Energy Commercialization.

This presentation discussed the main issues that characterize the present situation in the Colombian Electricity Sector regarding risk responsibility of supply. It was presented by Hector M. Hernandez, Dean of Engineering on behalf of Fermando Gomez.

Fermando Gomez G, is an Electrical Engineer**.** He graduated in 1967 from the National University of Colombia. He was for many years functionary of the Empresa de Energia de Begota after which he became a Consultant on Energy.

The final presentation was on present and future approaches to ensure supply adequacy in the Mexican Electricity Industry. It was prepared by Marcelino Madrigal and Francisco de Rosenzweig. Marcelino Madrigal is Director of Research and Regulatory Development at the Energy Regulatory Commission in Mexico, where he develops research and development in regulation and competition in electricity markets; Francisco de Rosenzweig is currently taking part in the design of a structural reform proposal for the Mexican electricity industry and in the North American Energy Working Group.

This presentation focused on how regulatory and legal changes in Mexico have modified the way investment in generation is made. A brief introduction of the evolution of the Mexican electricity sector, supply responsibility, and investment statistics on generation was given. Also discussed was the restructuring options that are being considered to cope with the foreseen supply problems in the future.

Marcelino Madrigal, Director of Research and Regulatory Development at the Energy Regulatory Commission in Mexico, received B.Sc., M.Sc. and Ph.D. degrees from I. T. Morelia Mexico, UANL Mexico, and the University of Waterloo, Canada, respectively. He has served as a consultant and instructor in software development and training for the national electricity company in Mexico. Here, he implemented the first training program on electricity markets since 2001 for the National Energy Control Center and in several other areas for the main public utilities in Mexico. His main areas of interest are the use of optimization tools for market design, simulation of market behavior, and regulation. He has authored and coauthored several papers on optimization applications to power systems at IEEE conferences and for Journals.

Francisco de Rosenzweig holds a Law degree from the Universidad Panamericana in Mexico City. He has worked as an Executive Assistant to the Director of the Legal Research Institute at the Universidad Nacional Autonnoma de Mexico (UNAM). He joined the Ministry of Energy, where he has participated in diverse interdisciplinary working groups focused on the analysis and promotion of schemes to finance and capitalize the energy sector.

The six presentations are summarized below:

RISK RESPONSIBILITY FOR SUPPLY IN LATIN AMERICA – THE ARGENTINEAN CASE

Jorge G. Karacsonyi[1]

Abstract

In deregulation of electricity sectors in Latin America two approaches have been used to allocate the responsibility on the electricity supply:

1) The government keeps the final responsibility on the supply. Suppliers (distribution companies or traders) do not have control on the rationing when it becomes necessary to curtail load. In such case they cannot manage the risks associated to the supply. This is the case in the markets of Brazil and Colombia.

2) The responsibility is fully transferred to suppliers. The regulatory entity supervises the quality of the supply and different types of penalties are applied when load is not supplied. This approach is currently used in Argentina, Chile and Peru. In Argentina the bilateral contracts, that are normally financial, become physical when a rationing event happens. This approach permits suppliers to have a great control on risks.

Both approaches have defenders and detractors. In some cases, the conclusions on a same event have completely opposite interpretations and diagnoses. For instance, the crisis of supply in Brazil during 2002 was interpreted as a fault of the market by the defenders of the final responsibility of the state, or attributed to an excess of regulation and of interference of the government by the advocates of decentralized schemes.

This presentation will analyze the performance of both approaches in Latin America, assessing the diverse types of arguments used to criticize or to defend to each one of these approaches, and finally to present some conclusions on the current situation and future of the responsibility on supply and risks associated.

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Introduction

The responsibility for the supply of energy in the Argentinean electricity market was allocated to distribution companies. Although there are different regulations for the distribution activity, because Argentina is a federal country, and electricity distribution activities are under the provinces jurisdiction, in most of the cases, regulation in the provinces followed the general principles established by the national government for a few distribution companies that are under federal control.

The process of restructuring and privatization of the Argentinean electricity sector started in year 1991. The more important decisions made by the government were:

- Unbundling of the integrated government owned utilities, in the activities of
  - Distribution
  - Transmission
  - Generation
- Large consumers, with a demand greater than 30 kW (1 MW in 1991) are allowed to buy their demand of energy directly to generators or traders
- Organization of a competitive wholesale market, with open access for generators, distributors and large users.
- Distribution and transmission companies must grant the open access to their facilities to generators and large users. For use of the transmission facilities, market participants must pay a regulated charge.
- Distribution are the last resort suppliers for both franchised customers and large users, in the last case when they do not to buy the energy in the wholesale market.
- Privatization of the Government owned utilities and most of the distribution companies property of the Provinces.

The Government quite of its role of operator, investor and planner, concentrating its functions in regulation and policy maker. As consequence responsibility in supply was almost completely transferred to the distribution companies.

Two institutions were created in the new organization of the electricity sector: the Regulatory Entity (ENRE) and the independent system operator, (CAMMESA), with role of market administrator as well.

Responsibility for Supply

The regulation clearly established that the responsibility of the supply was assigned to the distributing companies. This responsibility was expressed through different dispositions included in the Electricity Law (24,056), its by-laws, regulations and the concession contracts for distribution and transmission activities.

[1] Mr Karacsonyi is executive consultant and partner of Mercados Energéticos, consulting company specialized in regulation of energy sectors.

Within the legal dispositions, a few principles define how the supply is expected to be guaranteed :

- Obligation to connect to all customers demanding the service,
- Service quality regime, which includes compensations to the clients by supply interruptions,
- Penalties are applied whenever the supply is interrupted, regardless of the origin of the interruption: internal network problems, transmission failures or generation insufficiencies.
- If a deregulated client (large user) contracts its supply with a generator or dealer, the penalties that distributors must pay by interruptions are limited to those originated in faults of the distributor´s network.

These dispositions clearly show the regulation's goal to allocate to the distribution companies the final responsibility of supply to all the clients in their concession area. In other words, the risks associated with the supply provision are entirely borne by the distributing companies. The regulation grants as well to the distribution some tools to manage the risks associated with such responsibility:

- The supply contracts, in theory allow distribution companies to transfer to the generators the risks associated with the generating shortage. The modality of these contracts is analyzed below.
- A tariff regime that –potentially- assigns to the distribution companies the financial resources to make the investments needed in their internal networks to assure the service quality,
- The possibility that some investments in transmission be included in tariffs and transferred to clients, with the objective of improving quality of the supply.

Some aspects of regulation related with responsibility of supply are analyzed in the next sections: the regime of quality of the service, the supply contracts and the transmission regime.

Supply Contracts

The modality assigned to supply contracts is the main tool that distribution companies have to manage the risk associated to a generation shortage. Distributors are authorized to make supply contracts with generators or dealers. Although the contracts allowed by the regulation are financial (by differences), in case when generation falls short to serve all demand, they become physical. This means that when generation deficit exists, the operator of the system (CAMMESA) does not interrupt the service to the agents (distributors, large users) who have contracts with plants that are available and producing energy during the event. Of course, the amount of load that is not interrupted is limited to the capacity contracted and produced by the generator.

Therefore, the curtailments are applied only to the agents who buy their supply in the spot market. The curtailment to a load is applied proportionally at the capacity demanded by that load in the spot market.

Similarly, consumers can as well include in their contracts clauses that penalize the supplier(s) when their generation is lower than what had been agreed, during a rationing event, and the system operator decides to . curtail the load of the consumer.. It is expected that the generators will increase the sale price of energy as a compensation for the risks assumed when accepting the penalties.

But even without penalties, because the financial character of contracts, the generators that cannot honor their contracts with their own production during a period with forced supply interruptions, must buy the difference in the spot market at the denominated cost of unserved energy[2]. This high cost constitutes a strong incentive to generators with contracts to maintain the availability of their plants.

With these supply contracts, the regulation uses market mechanisms to encourage distributors to transfer their supply-associated risks to the generators.

However, some aspects of the regulation limited the effectiveness of these dispositions.

- Distributors are authorized to ´pass through´ the tariffs the costs of energy purchases valued at the spot market price. Therefore, if they make a supply contract, they must bear the differences between the price of energy in the spot market and the price agreed in the contract. As a result, the reduction in the supply risk implies taking a financial risk. This modality of pass through completely discouraged the distributors to sign supply contracts. Furthermore, during the 1992-2001 period, the supply quality was quite good, with only few generation-caused interruptions shortage.

[2] When a lack of supply arises, the regulation establishes that the price of the energy in the spot market is set at the so called " cost of unserved energy" . This is a cost representative of the social effect of interrupting the supply. According to the regulation, this cost depends on the percentage of demand not supplied, and starts at 120 us$/MWh (1.5% of deficit), reaching 1500 us$/MWh when deficit is greater than 10%.

- By 2001, distributing companies held contracts for less than 25% of their demand. Therefore, even though supply contracts constitute an effective tool for hedging the supply-associated risk, , since they also created financial risks they were practically not used by the distributing companies.

Regulation on Quality of Service

As consequence of the restructuring process, the Concession Contracts of the Public Service of Power Distribution included a regime of penalties. These are applied in the cases when concessionaires surpass the settled down limits of tolerance of Quality of the Service. The value of the penalties is given by the cost of unserved energy (VOLL). From the companies' point of view, , the penalties constitute the opportunity cost in which they incur if their investments are not enough to supply the forecasted demand with a number of interruptions below the regulation targets.

Since the beneficiaries of the penalties applied to the companies are the clients that were affected by interruptions to supply, these penalties are act as compensations. This penalties reflect the value that the society grants to electric energy and correlates the cost (tariff) paid by society to the real quality of service supplied by distributors.

The Quality of the Service provided by the companies franchised by the National Government is controlled by the regulatory entity, the ENRE, in the following aspects:

- quality of the technical service (frequency and duration of the interruptions)
- quality of the technical product (voltage level, disturbances)
- quality of the commercial service (response times to connect new users, estimated invoices, claims by invoicing errors or other reasons, time for restablishment of the supply suspended by lack of payment or other reason)

The Argentine regulatory framework and the Contracts of Concession of the distributing companies include original and innovating indicators of quality that push control to the clients level. It also implies the necessity to be able to identify interruptions, voltage levels and disturbances that affect each client. So that the deviations from the established limits trigger economical sanctions to the distributors. The amount of penalties paid by the distributors are credited to the users affected by the bad quality of service, applying discounts in the respective invoices.

The admitted maximum values for the variables that are controlled are the next:

Number of interruptions (every 6 month)	
Clients in high voltage (132, 220kV)	**2**
Clients in medium voltage (13.2, 33kV)	**3**
Clients in low voltage, large loads (220V, 3x380 V)	**6**
Clients in low voltage, small loads (220V, 3x380 V)	**6**
Time of interruptions (hours / sixth months)	
Clients in high voltage (132, 220kV)	**2**
Clients in medium voltage (13.2, 33kV)	**3**
Clients in low voltage, large loads (220V, 3x380 V)	**6**
Clients in low voltage, small loads (220V, 3x380 V)	**10**

Interruptions lasting 3 minutes or less are not computed for penalizations.

Finally, the compensation is computed based on the unserved energy valorized according to each user's tariff category according to the following unitary values:

- Tariffs 1 (residential, low demands),: 1,40 us$/kWh
- Tariffs 2-3 (medium demands): 2,27 us$/kWh
- Tariffs 2-3 (large demands): 2,71 us$/kWh

This methodology was remarkably effective to obtain substantial improvements in the quality of the service of distribution – in other words, the section of the network under the control of the distributors. Since the quality of supply in the external network (transmission and generation) also experimented a strong improvement (although for different reasons), between 1992 and 2001 consumers of electrical energy saw how the service interruptions were reduced dramatically.

A further comment on the quality regime. The penalties by interruptions to the service are valued based on the VOLL. This parameter, in order to be socially right, should represent the measurement of the willingness of the consumers to pay exactly that amount to avoid interruptions to the supply. The VOLL was determined in 1991, and hasn't been modified since then. Currently, several reasons exist to consider that this value should be updated, the strongest being the 300% argentine peso devaluation in early 2002 which wasn't reflected in any way in the VOLL.

The Role of Transmission

The restructuring of the transmission was clearly oriented to turn to this service a wholly independent activity, with strong incentives to the quality of the service, but with the expansion defined by the market. The transmission activity, unlike the distribution, is wholly regulated by the central Government. The service is provided by transmission companies (Gridcos), and regulated by the ENRE.

The outstanding aspects of the regulation of the transmission are:

- The Gridcos are passive companies, and consequently they do not have any responsibility on the expansion,
- Gridcos cannot make activities of purchase or sale of energy but for their own use,
- Gridcos must grant open access to his facilities to the agents whom they ask for connecting to the transmission network,
- The access requests are analyzed by CAMMESA in consultation with the incumbent Gridco and approved by the ENRE.
- Gridcos have concession contracts that include a regime of quality of the service with penalties for unavailability of their facilities,
- The expansions are decided by the agents of the market, and entrusted to independent carriers through a public bid. The facilities of the Gridcos are strictly used following the instructions issued CAMMESA, which means that the use of the transmission facilities is defined by the ISO rather than the Gridco.

Although the regime of the transmission has been criticized, most of the objections were based in the investment amount - smaller than in generation and distribution-, rather that in terms of economic efficiency. Objective elements of judgment demonstrate that there has been a remarkable increase of the efficiency in the use of the system of transmissions, and that the investments made were the only ones that were socially profitable.

The lower amount if investments in transmission is because the grid was over sized at the time of privatization, and because after saturation of the existing grid, new generation plants were installed near the cities, taking advantage of the lower cost of transportation of gas respect to that of transporting electricity.

The regulatory regime of the transmission was also very effective to encourage the Gridcos to dramatically improve their quality of service, mainly due to the regime of quality of service that is part of the concession contracts of the companies that were privatized, an also of the new independent Gridcos.

Nevertheless, there are two things to note in relation to the distributors' responsibility in the supply:

- The penalties that the Gridcos must pay by unavailability of their facilities are much smaller than the compensations than the distributors must pay to their users by faults in the transmission system This subject is directly bound to the size of the companies. The transmission activity, in the defined regulatory regime, would not be sustainable if it had to afford the cost of the interruptions to the service that can arise from faults in their facilities

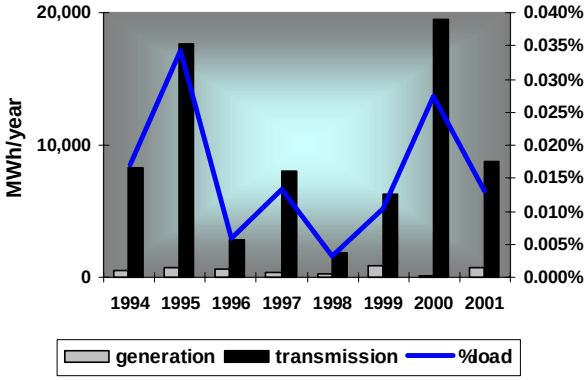
- The regime of pass through of the costs of transmission to the final tariffs does not allow that always the distributors can pass to their clients the costs of the expansions that they decide to sponsor. Therefore the general policy of the distributors has been of not promoting expansions, in order not to confront the risk of nontransferable costs to tariffs.

Regulation Performance

The results of the regulation can be considered very satisfactory from the point of view of the supply. The investments in generation widely surpassed the growth of the demand, turning to Argentina into an exporter of energy to Uruguay and Brazil.

The quality of the service of distribution also improved remarkably, as well as the quality of the transmission.

The following picture shows the energy unserved at wholesale level during the period 1994-2001, separating quantities originated in faults of generation and transmission. It is appraised that the percentage of energy cut in relation to the supplied demand represent values in the rank from the 0.01% the 0.04%. Also it is appraised that most of the provided energy is originated in faults of the transmission system, particularly in the system that ties the region of Comahue with the city of Buenos Aires. This system has four circuits of 500 kV and 1100 km length, that approximately transport 35% of the total demand of Argentina.



Conclusions

The transference of the final responsibility of the supply to the distribution companies seems to be an efficient form to assure the quality the service and expansion of the generation. By contrast, previous experiences in Latin America in which the Government assumed that responsibility, have been less satisfactory, and in general implied high social costs not always quantified.

However, this risk transfer must go together with giving to the distributors suitable tools for handling these risks.

- For the risks associated to the distribution network, the most efficient way to handle them is through a quality of service regime that encourages the investments necessary to reach the quality objectives. The tariffs must include the resources for these investments, as well as a reasonable return on them.

- For the risks associated to supply, particularly to generation availability, the obligation to supply all the energy requested by consumers is an efficient incentive for distributors. Conversely, the regulation should also provide distributors with the tools to manage their risks. One efficient way of achieving this would be to allow distributors to transfer the cost of energy they purchased by contracts, including the no-supply penalties. The regulator could make sure that these purchases were made in a competitive way to protect the consumers.

- The responsibility of supplying of the distributors could be limited to the clients who are not allowed to buy the energy in the wholesale market. The obligation could be limited to buy the energy demanded by these clients in the spot market without penalties in case of shortage. In any case, the network-related quality of service duties would remain.

- Deregulated users should be encouraged to manage their supply directly with generators, being able to model the quality of the service to its real willingness to pay.

Mr Jorge Karacsonyi obtained his Electromechanical Engineer grade in the Buenos Aires University. In the last years, as member of the Mercado Energeticos staff, he have been advisor of public entities or private companies in competitive markets of electricity and gas in twenty two countries. He was team leader of many studies committed to Mercados Energéticos, as electricity market design, tariffs calculation, economical and risk assessment of generation plants, transmission facilities and pipelines. He is professor of Comparative Regulation in the post grade course of "Mangement of Electricity Markets", in the Instituto Tecnológico de Buenos Aires (ITBA). Formerly he was president of the Energy Commission of the Centro Argentino de Ingenieros.

References:

[1] CAMMESA Yearly reports 1994-2001
[2] ENRE – 2001 Yearly Report

Electricity Markets - The Latin American Case
The Colombian Case

Fernando Gómez G., *Member, IEEE*

***Abstract*--The purpose of this paper is to present the main issues characterizing the present situation of Colombian Electricity Sector, regarding the risk responsibility of supply.**

I. Introduction

According to the Colombian Constitution, the State must guarantee the efficient supply of public services to the whole population in the national territory. Also, economic activities and private initiatives might be carried out freely.

As established by Law 143 of 1994, one of the Colombian State objectives is "supply electricity demand, under economic criteria and financial viability, assuring the coverage within a frame of rational and efficient use of energetic resources of the country".

In order to fulfill these aims, the law assigns to the State, among others, the following functions:

a. To promote free competition in the activities of the electric sector.

b. To prevent faithless competition practices or abuse of dominant positions in the market.

c. To regulate such situations, in which free competition does not provide guarantee of efficient supply, in economics terms.

In addition, the law, when developing the previously mentioned constitutional principles, opens the door to all economic agents, either publics, privates or mixes, so that they might act in the sector within a frame of free competition.

II. How Regulation seeks to guarantee the supply

In order to fulfill in a suitable way the State functions, as far as electricity supply is concerned, the Regulatory Commission ("Comisión de Regulación de Energía y Gas" - CREG) developed a regulatory framework which deals with generation, transmission, distribution and commercialization activities. One of the most important issue of such a regulatory framework is the establishment of a Block Energy Market ("Mercado Mayorista de Energía" - MEM). The market operating rules aim to encourage competitive processes in generation and commercialization activities, and to regulate monopolistic activities, that is, transmission and distribution.

III. Initial reaction of the agents

After overcoming the natural starting difficulties, initial steps of the new scheme were successful, as they advanced as designed: private investors acquired a big portion of the installed hydroelectric generation and also added new thermoelectric capacity, under their own risk. In the distribution sector, private investors capitalized the biggest company of the country, that provides electricity to the Bogotá City and their neighborhood. Furthermore, utilities attending the North Zone of the country were also bought by foreign private investors; The Block Energy Market began to operate, restricted initially to a small fraction of the consumption, in spot and bilateral contracts modes, evolving gradually, within a joint learning process, to a broader and wiser scheme.

IV. Environment evolution

Some non anticipated phenomena came to scene, causing disturbances to the process, which introduce threats to the stability of the scheme, putting in risk the supply, such as:

A. Prolonged period of economic recession

This caused a decreasing rate of demand growth (even negative), enlarging the gap between offer and demand curves and, therefore, stretching down market prices and generators income. In addition, this recession has weakened the consumers capacity to pay, so increasing their sensitivity to assume tariff adjustments which could be necessary for the market.

B. Frequent regulatory modifications and adjustments

Most of the regulatory events attempt to impact the maneuver capability and remuneration of generators agents, in order to prevent the assumption of dominant positions in the market, when certain circumstances occur. These are generally related to hydrologic events such as the "Child Phenomenon", or to breaking up of the network caused by terrorist attacks. Frequent regulatory modifications induce some level of distrust in the investors perception.

C. Lack of autonomy and independence of the regulatory entity.

The Minister of Energy, the Minister of Treasure and the Chief of the National Planning Department, all of them public officials and, therefore, State representatives, have seat in the Regulatory Commission. Moreover, the State has the property of a significant part of the electric system (generation, transmission and distribution), so it is an active actor in the competitive scheme. In other words, the State plays two antagonistic roles, acting as regulator and as regulated. Private investors have seen this dual participation of the State as an obstacle to maintain a sound scheme.

D. Problems in the distribution level.

Regional distribution utilities, owned by the State, have been immersed in an institutional and financial crisis long time ago. Some types of actions have been executed to seek for improvements to these concerns, looking for its privatization, but concrete results have not yet been obtained. Intervention procedures, in charge of the Audit and Control Entity (Superintendencia de Servicios Públicos - SSP) have not been successful, partially because of lack of technical and finance skills of the SSP. Being distribution the last link in the chain of electric service, it is the most visible part to the consumer, and it is the doorway for the sector income. Therefore, distribution inefficiency affects the whole process functionality, causing very serious consequences. Debts in arrears of this segment with generators in the Market, is another way of sending negative signals to present and potential investors.

Simultaneous presence of these factors configure a scenario of uncertainly about the survival of the scheme, therefore putting in risk the service supply in a perhaps not very distant future.

V. STRATEGY FOR A SOLUTION

Solutions to the problems described impose a number of challenges, the most important being to preserve scheme stability, consolidating the Energy Market (even expanding it to an international sphere) and making viable the future expansions.

Some actions have already been undertaken by the Government, such as:

1. To assign public resources to seek out the economic recuperation and to search for solutions to the internal armed conflict.

2. Let the utilities having State participation to work with a broader autonomy, so that, when operating with management criteria, they become more efficient and stronger companies than they have been in the past, thus making easier to advance in their capitalization process.

By the other hand, the Energetic Planning Unit (Unidad de Planeamiento Minero Energético - UPME), has recently formulated a number of recommendations, based on a joint work with the International Development Bank and Development Federation (Federación para el Desarrollo - Fedesarrollo), as the following:

1. To promote system expansion based on thermoelectric power plants, by fixing a remuneration level for them to compensate, in a suitable way, the additional reliability furnished by this type of generation.

2. To balance the competition level, by letting the installed plants to expand its capacity, beyond the present regulatory limits, in order to guarantee projected demand supply.

3. To reinforce the coordination levels between Regulatory, Supervisory and Planning institutions.

4. To adequate the market intervention mechanisms and to define rules for system operation in disrupted net conditions, in order to maintain a highly competitive market.

5. In a long term view, to promote the auto generation and the efficient use of the energy. In these concerns some advances have already been made.

VI. REFERENCES

[1] J. Villarruel, "Plan de Expansión de Referencia Generación Transmisión 2001-2015", Unidad de Planeación Minero Energética UPME, October 2001

[2] J. Gutiérrez, "El Sector Eléctrico Colombiano, Orígenes, Evolución y Retos", Interconexión Eléctrica, S.A. ISA, December, 2002

[3] U. Ayala, J. Millán, "La Sostenibilidad de las Reformas del Sector Eléctrico en Colombia", Cuadernos de Fedesarrollo No. 9, January, 2003

VII. BIOGRAPHIE

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Ensuring Energy Supply Adequacy In Market-Based Systems: The Brazilian Experience

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***Abstract*— The objective of this panel presentation is to briefly assess the present stage of the Brazilian power sector reform, evaluating the 2001 energy crisis, its effects and proposals for power sector model improvement. In this process the Brazilian government faces a considerable number of challenges, of which we will concentrate on the following ones in more detail: price signals and operational reliability, and investment and supply security in the long term. We will evaluate the most recent proposals and alternatives for ensuring security of supply in Brazil, and also assess alternatives and proposals learned from other countries' experiences.**

Index Terms-- Hydroelectric power generation, risk analysis, energy market, economic efficiency

I. PRESENTATION SUMMARY

Brazil is the largest and most populous country in Latin America, with 8.5 million square kilometers (the size of continental U.S. plus half of Alaska) and a population of 175 million inhabitants. The installed capacity is 82 GW and 98% of the load is supplied by an integrated high-voltage grid. The power system is hydro dominated (85% of the current installed capacity and 90% of the energy produced, both in 2002), with large hydro plants in cascade over several basins, including the 12.6 GW Itaipu binational hydropower plant.

The current market design is a result of an institutional reform process initiated in the mid-90s, motivated by the lack of public sector resources to invest in the infrastructure required to meet load growth. New institutions were created, including a regulatory body (ANEEL), an independent system operator (ONS), and a wholesale energy market (MAE).

The distribution and transmission sides of the reform were successfully implemented. Most distribution utilities were privatized, distribution services were modernized, and private companies started to play a major role in new transmission project developments. The generation side had a good start, with the privatization of four state-owned companies. However, due to political opposition, the process did not go further. As a consequence, around 85% of the generation capacity remained under government control.

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In the meantime, the seeds for the 2001 supply crisis were planted. An imbalance between firm supply and demand, coupled with delays in supply reinforcements and interconnection links, led to a slow depletion of the system's reservoirs along four years. The combination of these effects with an unusually low wet season in early 2001 triggered a major energy crisis, which resulted in an energy rationing during 9 months (part of 2001 and 2002). Rationing was declared in three of the four regions of Brazil – Southeast, Northeast and North – comprising roughly 80% of the country's GDP and population.

Although rationing was successfully managed, due to the strong cooperation from the population, which managed to reduce overall consumption by over 20%, and to an effective government action and management of the crisis; it affected the public perception of the power sector reform. The government, in parallel to the rationing management tasks, launched a major program to "revitalize" the system's institutional framework and commercial model, putting forward several proposals towards strengthening competition and market institutions, taking into account the complexities of the Brazilian power sector and the partial achievements of the transition period. The present institutional framework and commercial model are the result of the interaction between pre-existing rules and contracts, reform efforts, opposition to reforms and the aftermath of the energy crisis.

The crisis, together with government incentives for new plants, spurred a major expansion in generation which, coupled with demand reduction during rationing, slow recovery and lower than expected growth rates after rationing, led to an excess of supply over demand that may last some years. This oversupply scenario has triggered a debate on how the mid and long-term generation adequacy may be assured, i.e., how to ensure an economic and reliable expansion of supply. The longer-term equilibrium of supply and demand in Brazil results from the commercial logic of the power sector model: given that merchant plant operation is quite risky (due to a high spot price volatility), most new generation will enter only if offered a long-term bilateral contract by loads (to guarantee the settling of its project finance and market entering). Bilateral contracts in the Brazilian power market are purely financial hedges. In turn, load is expected to be almost 100% contracted (a minimum cover of 95% is established by regulation), but no more than that, since if rationing occurs again bilateral contracts will not give any

exemption or priority to contracted loads – they will be provided, at most, financial compensation. This way generation capacity will tend to "track" load increase. Furthermore, each of these contracts must be backed up by actual physical generation assets capable of producing enough power to fulfill the contract in a sustainable way, in order to assure a desirable supply reliability level. This can be either physical generation capacity (in the case of thermal plants), or the assured energy certificate[1] of hydro plants. This mechanism ensures that bilateral contracts effectively contribute to the financial feasibility of new generation and, thus, to an adequate reliability level. In other words, the demand for new contracts to cover load growth acts as the main "driver" for generation expansion, rather than economic signals from the spot market.

However, this mechanism recently showed some inadequacies, as even though the load was 100% contracted, with physical backing, the country had a severe energy supply crisis in 2001 as mentioned before. This led to a preliminarily evaluation that difficulties with the physical backing could have been one possible reason for the emptying of the system reservoirs over four consecutive years.

Since the current short-term prices are very low and the contract opportunities for new entrants are scarce at the moment (both consequences of the oversupply scenario), instruments for ensuring generation adequacy constitute an important subject in the power market improvement mechanisms.

In Brazil there are no capacity markets, such as the operable capability (OpCap) and installed capability (ICap) markets[2] adopted in the New England and PJM's power market. These markets are intended to promote reliability by assuring that there is sufficient capacity in the system to cover the peak load plus a reserve margin. Furthermore in Brazil there are no capacity payments such as those first adopted in the UK power market in the 90's.

Another recent approach to promote reliability and to encourage supply expansion, but also not adopted in Brazil, is to have capacity products traded through market-driven financial instruments, such as financial options that consumers (distribution companies, traders) would have to buy from generators in a primary or secondary market. A liquid options and futures market could be created, where consumers would be able to buy these financial instruments. Among possible advantages of this schemes could be the revelation (disclosure) of the true value of the capacity once this market is competitive, since the price of the capacity would not be set any longer "externally" (as for example in capacity payments scheme), instead, it would be a value assigned by the market (prices at which participants are really willing to sell or to buy). Furthermore it is expected that the possibility to decentralize the administration of the physical risks associated to non-supplying the demand, as for example, financial options exercised with the possibility of physical delivery, would allow to decentralize the chain of decisions and would let each type of consumer choose its appropriate combination of price and quality, thus increasing the social benefit associated to energy consumption.

In one way or another, it is important to distinguish "supply security" or "capacity" contracts from financial hedging contracts. Capacity contracts are usually designed to insure against quantity risks (risk that sufficient supply is not available), while financial contracts are designed to insure against price risks (risk that supply becomes too expensive). Sometimes the two types of contracts are combined, such as the energy bilateral contracts (fixed amount of "assured" energy traded at a fixed price) traded in the Brazilian system that drive system supply expansion. Restrictions on the available types of contracts reduce the freedom of market agents to choose for themselves the extent to which they are insured against quantity and price risks.

These issues have been raised in an ongoing debate involving the agents of the Brazilian power system on its options for ensuring security of supply, since it is essential to ensure a reliable and economic expansion of supply for the country. For example, an important measure recently implemented was the creation of a compulsory auction mechanism for distribution companies to sign long-term PPAs.

The objective of this panel presentation is to briefly assess the present stage of the Brazilian power sector reform, evaluating the 2001 energy crisis, its effects and proposals for power sector model improvement. In this process the Brazilian government faces a considerable number of challenges, of which we will concentrate on the following ones in more detail: price signals and operational reliability, and investment and supply security in the long term. We will evaluate the most recent proposals (e.g. assessment of the PPA auctions for distribution companies) and alternatives for ensuring security of supply in Brazil, and also assess alternatives and proposals learned from other countries' experiences (e.g. financial options).

[1] Concept somewhat similar to firm energy of a hydro plant. Assured energy is defined as the energy that has a 5% chance of not being supplied in any given year.

[2] ICap is a monthly market and OpCap is a daily market.

II. References

[1] C. Vázquez, M. Rivier, I.P. Arriaga, "A Market Approach to Long-Term Security of Supply", IEEE Transactions on Power Systems, Vol. 17, No. 2, May 2002.

[2] S.Borenstin, "The Trouble with Electricity Markets (and some solutions)", UCEI, POWER Working Paper PWP-081, 2001

[3] S.Stoft, "PJM's Capacity Market in a Price-Spike World", UCEI, POWER Working Paper PWP-077, 2000

[4] P. Cramptom, "Electricity Market Design: The Good, the Bad, and the Ugly", Proceedings of the Hawaii International Conference on System Sciences, January, 2003

[5] T.Hammons, H. Rudnick, L.A.Barroso, “Latin America: Deregulation in a Hydro Dominated Market”, Hydro Review Worldwide, vol. 10, No. 4, September 2002

[6] Velásquez, J. “Stochastic Optimization And Risk Analysis Of Long Term Electricity Trading”, Special Volume On "Or Models For Energy Policy, Planning And Management",Annals of Operations Research, 2003

[7] N.H.Von der Fehr, D. Harbord, “Capacity investment and long-run efficiency in market-based electricity industries” in Ole Jess Olsen (ed), Competition in the Electricity Supply Industry: Evidence from Europe and the United States, Copenhagen: DJØF Publishing, 1995.

III. BIOGRAPHIES

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Risk Responsibility for Supply in the Brazilian Energy Market

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***Abstract*--The purpose of this paper is to contribute to the discussion on the supply problems faced in Latin America electricity markets over recent years, and how markets and regulations have worked in relation to allocating the responsibility for supply. It presents some remarks on causes and consequences of the recent rationing in the Brazilian power system. The paper also review the actions that were undertaken and issues that are under review to reduce the likelihood shortages future as weal as to attribute responsibilities.**

***Index Terms*—Economic efficiency, energy market, resource scheduling, optimisation models.**

I. Introduction

THE restructuring of the Brazilian electricity industry was meant to improve the economic efficiency of the utilities and of the power sector as a whole, reduce the prices for electricity, increase the reliability and quality of supply, attract private investments, and ensure enough generation and transmission capacity to supply the consumers, considering a high demand growth rate.

Like in many other countries, the goal was to introduce fair competition in the generation and supply sectors, by ensuring free entry, open and non-discriminatory access, and transparent rules and regulations. To establish an equitable and efficient energy market, essential requirements, which prevent the introduction of opportunity for the exercise of monopoly power to particular agents, have to be met [4-7].

However, achieving the adequate level of competition in the power sector, like in every industry organised in a network framework, is not a trivial task. It is even more difficult when the different segments of the chain can run total or partially unbundled. The problem becomes more complex when the "network link" of the chain is a natural monopoly and its neighbouring links are subjected to competition [1-3].

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Measures like unbundling - vertical segregation of the biggest utilities - have been encouraged, but not fully implemented in Brazil.

This paper contributes to the discussion over the risks of not attending the demand requirements and the responsibilities associated to an eventual energy shortage. The experience of the undesirable rationing, recently experienced by Brazilians, is revisited in an attempt to raise some questioning and remarks over the issue. The paper describes briefly the security constrained scheduling and dispatch models used in Brazil, and highlights some structural changes under review for the Brazilian energy market.

The paper is organised into three sections following this introduction. Section II brings a brief introduction of the Brazilian power system and the main features of the Brazilian market framework are presented in Section III. Details of the 2001/2002 Brazilian rationing are presented in Section IV. Section V brings the most relevant remarks on the issues discussed in the paper.

II. The Brazilian Power System

The Brazilian power system is hydro-dominated, in which the installed capacity of 80,855 MW is composed of 81% of hydro plants, 17% of thermal plants and 2% of nuclear plants. Several hydro plants are installed in cascade of the same river basin. The large reservoirs are characterised by multi-annual regularization and are distributed over several hydro basins. The annual energy demand of the 47 million consumers is around 300 TWh. The system is also characterised by long bulk transmission links, such as the set of a.c. and d.c. transmission lines that transport almost 12,600 MW from Itaipu, and high demand growth rate. It was originally vertically integrated and mainly state-owned. Before the restructuring, it has experienced limited financial resources for expansion and lack of incentives towards efficiency.

III. The Brazilian Energy Market

The Brazilian electricity market can be described by: compulsory trade through the market operator (MAE), centralised cost-based scheduling and dispatch by the system operator (ONS), *ex-ante* weekly locational marginal prices, passive demand, and independent regulating agency (ANEEL), indicative generation and transmission expansion planning

performed by a specialised committee (CCPE) under the responsibility of the Ministry of Mines and Energy (MME), and government policy and guidelines set by the National Congress.

A. Scheduling and Pricing Models

The hydrothermal coordination problem can be described as the search of the optimal balance between (*i*) use the water resources today - reducing the immediate costs and increasing the future costs – or (*ii*) save the reservoirs for future use – increasing the immediate costs due to the thermal generation and reducing the future costs. The wrong decision can lead spillage or energy shortage.

The planning horizon varies from years to hours. Hence, the optimisation of the energy resources is achieved by disaggregating the hydrothermal coordination problem into long-term (5 to 15 years, on monthly basis), medium-term (1 year, on weekly basis) and short-term (1 week, on hourly basis) operation problems.

Essential information for the operational problem is the forecast of water inflows, the load profile, the network configuration, the availability of hydro and thermal plants, and the generation and transmission expansion planning [9].

Several energetic and electric constraints are taken into account. Examples of constraints are: water balance (the inflow water equals to the sum of turbined water, spillage, evaporation, and incremental storage), demand requirements, minimum stable generation, maximum generation capacity, storage capability, system reliability and security constraints, and transmission rates.

The system operator uses a chain of optimisation models to determine the scheduling and dispatch at minimum total operation costs [8]. The models use the technique of Dynamic Dual Stochastic Programming to determine the units' generation profile for each planning horizon and to calculate the short-run marginal operation costs.

The market operator uses the same models to determine the market-clearing price.

The Brazilian system is composed of around 70 reservoirs. To reduce the computational burden and to represent their hydrological interdependence they are aggregated into four equivalent reservoirs. Four subsystems are then represented by their corresponding aggregated reservoir, in which the main characteristics are the capacity and the inflow energy. The former is estimated by the amount of energy that could be produced by using the total storage water of all reservoirs of that subsystem, whereas the latter is equivalent to the sum of controlled energy and the run-of-river energy.

B. The Energy Reallocation Mechanism (ERM)

Several generation owners are located in the same river basin. Those agents do not control their generation dispatch due to the centralised optimisation of the global resources. To mitigate the hydrologic risks and the effects of the optimal use of water in cascade units the Energy Reallocation Mechanism (ERM) has been introduced. The ERM is system-wide, i.e., it applies to the whole market. Hence, the effects of the hydrological diversity between basins are also considered.

In simple terms, the ERM allocates an energy credit to each hydro plant (and to some thermal plants), which is a share of the sum of the hydroelectric production of all plants in the ERM club. This energy credit is proportional to the plant assured energy, which is the amount of energy that a generating plant is entitled to commercialise through bilateral contracts [14].

The computational models used for scheduling and dispatch and for determining the market-clearing prices are also used to calculate the system and units' assured energy. Essential premises are assumed: constant market in the planning horizon (5 years), static system generation capacity, and 5 years of previous studies (to remove the effects of the initial volumes of the reservoirs).

Based on historic information of previous years, 2000 synthetic series of water inflow are calculated. The percentage of series that does not satisfy the existing market is determined. If the market is not satisfied in more than 100 (5%) series, the market is adjusted (reduced). The average energy generated by the system with a 5% risk of deficit is named system guaranteed energy.

The System assured energy is calculated as 95% of the system guaranteed energy. The units' assured energy is a share of the system assured energy, proportioned to their individual firm energy.

Firm energy is defined as the average amount of energy that a unit can produce over the system critical period, which is the period of study comprising the time when the reservoir is full to the time when the reservoir reaches its minimum quota.

The Brazilian assured energy is about 5.4% higher than the system firm energy.

The assured energy of a plant is used for accounting and clearing in the wholesale electricity market. Each plant is like a shareholder of a big holding company that controls all the production of the system. The plant contributes to the total production of the holding, without management over the amount of energy it should dispatch, and is entitled to some

revenue, in energy terms, proportioned to its share and not to its individual production.

C. The Brazilian Sub-markets

The number of sub-markets is a function of permanent transmission constraints, in other words, sub-markets are defined for geo-electrical areas that do not have transmission constraints considered permanent or with a high likelihood of occurrence [10-12]. The clearing prices for the sub-markets are different, and whenever competition amongst agents in separate sub-markets is possible, the clearing price is higher for the agents that are in the importing sub-market, given the monopoly power due to the constraint in the transmission link, as it is shown in Section VI. Conversely, whenever the transmission constraints are temporary, then there is a natural increase in the competition level, and the clearing prices will tend to the marginal costs of the "cheapest" sub-market.

Determining the most appropriate number of sub-markets for a power system is an extremely complex task and depends not only upon technical issues, but also upon political arguments, such as the definition of the desired level of competition [13]. Considering the features of the power system and the characteristics of the hydrothermal resources, four sub-markets have been defined for the Brazilian market.

IV. THE RATIONING

A. Description

Starting on June 2001 and ending in February 2002 the Brazilians consumers in the Northeast and Southeast regions were subjected to a compulsory 20% energy reduction, due to the high depletion of the water reservoirs. An energy compulsory reduction (around 10%) was also imposed to the Northern consumers. Bonuses were proposed to incentive customers to reduce their consumptions beyond that limit, and penalties were introduced for those customers that did not manage to reach that target.

B. Causes

Specialists have been arguing that the energy shortage was a natural consequence of a non-optimal operation of the energy resources for many consecutive years. They state that the true scenarios were not taken into account properly, and believe that several aspects contributed somehow towards the rationing, as such:

Postponement of Generation and Transmission expansion projects;
Unexpected limitation on financial investments for continuous years – even before the establishment of the Brazilian Energy Market;
High demand growth in several regions;
Unforeseen droughts leading to extremely reduced inflow;
Uncertainties not well handled by the optimisation models;
Lack of attitude by government institutions;
Scheduling and dispatch by models that do not take into account the true characteristics of the power system;
Electricity prices that did not reflect true market opportunities.

The lack of definition regarding responsibilities contributed significantly to the scenario of energy shortage.

The distribution companies (DISCOS), which are responsible for supplying, were bounded by bilateral contracts (Initial Contracts) on the basis of guaranteed energy. The guaranteed energy is calculated taken into account the generation and transmission expansion plan, which was not fully implemented.

The generating companies (GENCOS) considered themselves immune to the commercial risks associated to any generation reduction, due to the Energy Reallocation Mechanism (ERM).

The Ministry of Mines and Energy (MME) believed that the market itself would provide proper signals and somehow take care of the adequate generation and transmission expansion.

It has been argued that the regulating agency (ANEEL) was more concerned on make those thermal plants viable without impacting the tariffs. Moreover, the expansion planning committee (CCPE) failed to fulfil its role properly.

Some gas thermal power plants, which were part of the generation expansion planning, were not commissioned in time mainly due to the sharp decline of the Brazilian currency compared to the American Dollar. Some others were called out due to the non-viability of their project finance, again due to the unfavourable exchange rate, and also because they would require to be run on the basis of the load curve, like must-run units, to support their *take-or-pay* contracts for gas.

Whenever those units were assumed to be available in the planning time horizon, a natural solution of the optimisation problem would be use more water from the reservoirs in the short time frame. As they were postponed or even called out, the models for hydrothermal coordination failure to proper schedule and dispatch the existing units, contributing to reducing the level of the reservoirs beyond that required to supply the demand long time frame.

Even with a considerable increase in the installed generation capacity (new thermal power plants were actually commissioned), there was not enough generation during the rationing, mainly due to the lack of water.

Additionally, transmission constraints were expected to be reduced in a short-term horizon, but it did not happened

accordingly. Hence, great amount of energy surplus in the South and North regions, were not able to reach the Southeast and Northeast regions. There were even a few reservoirs that experience water spillage.

C. Consequences

The consequences of the rationing were severe for the electricity industry and also for the Brazilian economy as a whole. It also considerably affected the image of government institutions.

Even after the end of the rationing, the energy consumption did not returned to the levels before the shortage. Domestic consumers changed their habits significantly and are much more concerned about using electricity more efficiently. Commercial and industrial loads are also on lower levels.

The DISCOS and GENCOS had their income extremely reduced due to the energy shortage. They had to enter in an agreement to manage the reduction of the consumption as for their bilateral contracts. This was extremely tiring time-consuming and required the help of the regulatory agency and the Ministry of Mines and Energy.

The cost of the rationing was split between customers, DISCOS, GENCOS and the government. The final customers were subjected to an increase in the tariffs, the DISCOS and GENCOS accept some reduction in their revenue, and the government provided some loans to DISCOS and GENCOS, through National Bank for Social and Economic Developing BNDES.

D. Actions in Place

The government has created a Revitalization Committee to assess fundamental issues of the Brazilian energy market. The Ministry of Mines and Energy (MME) has been given final responsibility for the supply. A new committee, under the responsibility of MME, has been created to assess the risk of deficit.

A new mechanism for risk aversion in scheduling and pricing was issued by a chamber of MME, in an attempt to reduce likelihood of rationings and to determine prices less sensitive to short-run inflow variations.

The government has introduced a special program for new gas thermal power plants (PPT) to help mitigating the supply problems. In this program there were some subsides for investors in gas thermal units.

The government has also provided incentives for some emergency thermal power plants and created a dedicated company to commercialise their generation (CBEE). These plants receive capacity payments and are scheduled to generate only in the event of energy shortage, i.e., they are not dispatched due to electrical constraints, but only due to energetic restrictions.

E. Issues under Review

The revitalization Committee is still reviewing issues like:

Scheduling and pricing based upon bid prices and offers;
New market rules and regulations;
Renewable energy;
Unbundling;
Mandatory level of bilateral contracts;
Generation reserve margin;
Self-dealing;
Incentives for gas-fired plants.

V. CONCLUSIONS

This paper has discussed some fundamental issues of the Brazilian electricity market design. It focused on the discussion over the risks and responsibility of the rationing recently experienced by Brazilian Customers. The authors argued that a proper definition of responsibilities is crucial for the success of the Brazilian energy market. They add that in a power system with a high demand growth rate, it is dangerous to leave the responsibilities for the supply on the hands of market itself. The cost of the rationing is too high to allow the planning be only indicative for the market participants.

VI. DISCLAIM

The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors and should not be attributed in any manner to ANEEL, or to its Board of Executive Directors. ANEEL does not guarantee the accuracy of the data included in this paper and accepts no responsibility whatsoever for any consequence of their use.

VII. REFERENCES

[1] M. Armstrong, "Regulation and Inefficient Entry: Economic Analysis and British Experience", Discussion Paper, Department Economics of the Oxford University, November 1999.

[2] R. Green, "Increasing Competition in the British Electricity Spot Market", The Journal of Industrial Economics, v. XLIV, n. 2. p. 205-216, 1996.

[3] P. L. Joskow, "Asset Specificity and the Structure of Vertical Relationships: Empirical Evidence", Journal of Law and Economics, v. 4, n. 1, 1988a.

[4] L. M. B. Cabral, "Introduction to Industrial Organization", The MIT Press, Cambridge, Massachusetts, 2001.

[5] P. L. Joskow, and J. TIROLE, "Transmission Rights and Market Power on Electric Power Networks", RAND Journal Economics, v. 31 (3), p. 450-487, 2000.

[6] M. Armstrong, "The Theory of Access Pricing and Interconnection", Working Paper – Nuffield College, Oxford, February 2001.

[7] M. Armstrong, C. Doyle, and J. Vickers, "The Access Pricing Problem: a Syntheses", The Journal of Industrial Economics, v. 44, n. 2, p. 131-150, 1996.

[8] M. A. M. Rodrigues et alli., "Chained System of Energetic Models", *in Proceedings of the XVI National Seminar of Electric Energy Production and Transmission - SNPTEE*, Campinas, Brazil, October 2001 (in Portuguese).

[9] M. E. P. Maceira et alli., "Hourly Generation Dispatch with Detailed Representation of Hydraulic Constraints", *in Proceedings of the VII Symposium of Specialists in Electric Operational and Expansion Planning - SEPOPE*, Campinas, Brazil, October 2001 (in Portuguese).

[10] S. M. Harvey, and W. W. Hogan, "Nodal and Zonal Congestion Management and Exercise of Market Power", Working Paper, Harvard University, 2000.

[11] T. Johnsen, S. K. Verma, and C. Wolfram, "Zonal Pricing and Demand-side Bidding in the Norwegian Electricity Market", Discussion Paper, NBER, 1999.

[12] National Electricity Market Management Company Limited - NEMMCO, "Formulation of Intra-regional Constraints", Issues and Options Paper, Version Nº 2, 2002.

[13] D. M. Newbery, "Competition, Contracts, and Entry in the Electricity Spot Market", RAND Journal of Economics, v.29, n. 4, p. 726-749, 1998.

[14] A. C. G. Melo et alli., "Evaluation of the Impact of the Energy Reallocation Mechanism in the Financial Risk of Hydroelectric Projects", *in Proceedings of the XVI National Seminar of Electric Energy Production and Transmission - SNPTEE*, Campinas, Brazil, October 2001 (in Portuguese).

[15] S. Borenstein, J. Bushnell, and S. Stoft, "The Competitive Effects of Transmission Capacity in a Deregulated Electricity Industry", RAND Journal of Economics, v. 31, n. 2, p. 294-325, 2000.

[16] R. GREEN, and D. M. NEWBERY, "Competition in the British Electricity Spot Market", Journal of Political Economy, v. 100, n. 5, p. 929-953, 1992.

[17] C. D. Wolfram, "Measuring Duopoly Power in the British Electricity Spot Market", American Economic Review, v. 89, n. 4, p. 805-826, 1999.

[18] S. BORENSTEIN, and J. BUSHNELL, "An Empirical Analysis of the Potential for Market Power in California's Electricity Industry", Journal of Industry Economics, v. 47, p. 285-324, 1999.

[19] R. Gilbert, K. Neuhoff, and D. Newbery "Allocating Transmission to Mitigate Market Power in Electricity Networks", Working Paper, University of California Energy Institute, 2002.

[20] W. W. Hogan, "Transmission Investment and Competitive Electricity Markets", Working Paper, Harvard University, 1998.

[21] Y. T. YOON, and M. D. ILIC, "Transmission Expansion in the New Environment", Energy Laboratory, MIT, 2000.

[22] U. S. Department of Energy - DOE, "National Transmission Grid", 2002.

[23] P. L. Joskow, and E. Kahn, "Identifying the Exercise of Market Power: Refining the Estimates", Working Paper, MIT, July 2001.

VIII. BIOGRAPHIES

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Risk Responsibility for Supply in Deregulated Electricity Markets- The Chilean Case

Hugh Rudnick, IEEE Fellow

Abstract-- **The presentation reviews the supply problems faced in the Chilean electricity market oven recent years, and how market and regulations have worked in relation to allocating the responsibility for supply. The risks associated with that responsibility are discussed and how Chile has taken actions in this regard, and the consequences of those actions. The Chilean regulation transfers full responsibility to suppliers. In theory, different types of penalties and compensations are applied when load is not supplied; in practice they have been difficult to put into operation. The presentation analyzes the performance of this approach, the crisis faced in 1998-1999 and the changes introduced to the regulation due to that crisis. Conclusions on the effectiveness of the regulations and the changes are developed as well as an assessment of unexpected impacts in the market.**

***Index Terms*--Power sector deregulation, electric market, supply reliability, risk allocation.**

I. INTRODUCTION

Throughout the world, the power industry is in the midst of important changes in the structure of its markets and their regulation. The primary trend of this restructuring is to promote competition, mainly in the generation sector, liberalizing those markets and allowing access to private agents. In this manner, the traditional large state owned vertically integrated companies are being segmented and different legal organizations are created to try to regulate the operation of these new competitive generation markets. Chile was a pioneer country in Latin America and the world to make these regulatory changes in 1982. Several other Latin American countries followed close after.

With no paradigm to rely on, the regulatory changes had to innovate to cope with unforeseen problems, often choosing solutions that did not prove to work well in major system crisis [11]. This was painfully true when supply crisis were faced, either because of impacts of nature (major droughts for example) or failures of equipment. This was the case of Chile, where the restructuring process worked well, minor problems faced, until a severe centennial drought hit the country in 1998-1999. A severe supply disruption took place with rolling blackouts, conflicts among electricity companies and with the regulator, and a significant social and economic impact on society, which led the country to hurried emergency changes to the electricity law.

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II. THE CHILEAN MARKET

There are two interconnected power systems in Chile, one of which, the Central Interconnected System (SIC), which supplies over 93% of the country population, is the object of this analysis. The system corresponds to a longitudinal network with 500 and 220 kV lines, and an installed capacity of 6,737 MW in 2002, 60.2 % of which is hydro. Annual energy consumption in that system was around 26,000 GWh in 2002.

A condition that may makes Latin American markets, and the Chilean one, very volatile is the predominance of hydroelectricity generation. In a rainy year, such as 1972-1973 or 1992-1993, nearly all the energy requirements in the SIC can be supplied with hydro generation. However, during an extreme drought such as those of 1968-69 or 1998-99, hydro generation cannot supply more than 40% of annual consumption [6]. In an average year, about 80% of annual consumption can be supplied with hydro generation.

In those conditions, the impact of an adequate reservoir usage on system security cannot be over emphasized. A system with a large fraction of hydropower is subject to constant changes in supply and costs and to periods of very tight capacity (i.e. during droughts), so that the regulatory design needs to deal explicitly with this issue.

III. THE REGULATION

The Chilean regulation aims at providing price signals to agents, so that they not only are interested in continuously invest to supply an increasing demand, but also, take provisions to face equipment failures (that may affect thermal plants) or droughts (that may leave a hydro plant with enough capacity, but without energy to supply).

A) Energy and Capacity prices

First, there are energy and capacity price signals. Consumers pay the two components. Regulated consumers, those under 2 MW, pay projected energy generation spot prices (nodal prices), calculated every six months by the regulator. They also pay regulated capacity payments (based on the annual cost of installing a new diesel fuel gas turbine generation facility). Consumers over 2 MW directly negotiate energy and capacity prices with the suppliers, but the regulated prices are a strong reference.

The capacity payment is the element of the regulation that aims at providing economic signals for new installed capacity,

fundamental in markets with significant growth and highly subject to supply shocks (e.g. droughts). While in theory energy spot prices provide the right incentives for new investments, several market analysts argue that in electricity markets such energy price signals are insufficient and can lead to under investment [12]. In that regard, most of the actual Latin American regulations, including the Chilean one, contain a provision to prevent that from happening; the so-called capacity payments. It often remunerates investment in generation by its contribution to peak capacity, independent of its energy contribution.

It must be pointed out that apart from the regulated prices, the energy spot price is used for exchanges among generators, while the non-regulated prices are freely negotiated between suppliers and consumers over 2 MW.

B) Compensation payments

Second, the regulation contemplates the payment of compensations to consumers, when the contracted supply is not available. Deficit generators (those that do not have enough energy available to supply their contracts) have to pay compensations at much higher prices than typical production costs (the non supply or outage cost, determined by the regulator) [2,3]. The aim of the regulation is that, in supply crisis, those deficit generators will look for supply alternatives, so that they do not have to pay those compensations.

However, the regulation also defined exceptional conditions where those compensations were exempted. A prolonged drought, that was not in the 40-year statistics used by the regulator to calculate regulated nodal prices, would be such a "force majeũre" condition. This was defined in article "99 bis" of the regulation.

Compensations have to be paid through the distribution companies to the regulated consumers. The calculation of the nodal prices, in theory, incorporates an insurance payment that considers the 40-year hydrology scenario used by the regulator.

C) Contracts

Financial bilateral contracts are an important element in the Chilean market, and also contribute to share the responsibility in the supply. Given the high price volatility that may take place in the Chilean hydro system, hydro generators have tended to extensively contract to face the income variability. In the short term the volatility of the income is small, since water can be stored transferring energy from off peak hours to peak hours, but that is not the case in the long term. Thus, contracts become a valuable tool to stabilize revenues. The more capacity contracted the less the impact of spot prices on generator revenues.

Through contracts, at least in theory, supply is ensured and generators will take actions to comply with them.

IV. THE CRISIS

A severe centennial drought started to hit the country in 1998, caused by the La Niña phenomenon. The April 1998- March 1999 hydrological year was worse that the previous recorded worse draught (1968-1969). Flows to the main reservoir, Lake Laja, were 65% of those of a normal year and 35% less than those of 1968-69 [7,10]

This extreme condition worsened because a new natural gas combined cycle, Nehuenco, with 370 MW, that was supposed to start operation in April 1998, was repeatedly postponed until December 1998. Then, in March 1999, it had a major failure that left it out throughout the entire crisis.

Although there was enough installed capacity in the SIC, there was no hydro energy to make the plants work. Figure 1 illustrates the dramatic reduction of energy storage in the main system reservoir, Lake Laja.

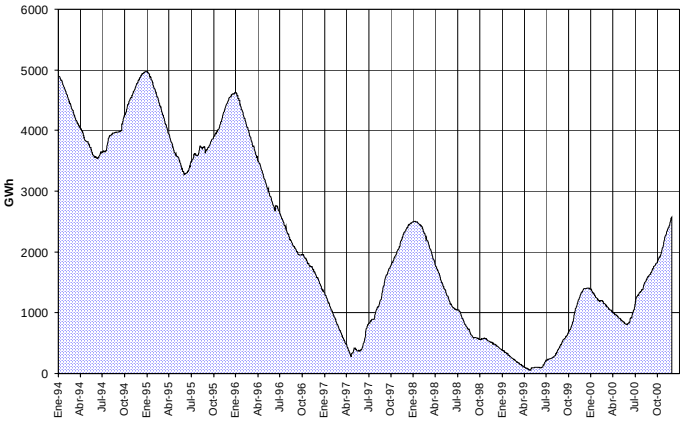

Figure 1: Evolution of the Laja reservoir level

A severe supply disruption took place with rolling blackouts. Electricity supply in Santiago was curtailed three hours a day, when over 450 GWh were not available for supply, with a significant social and economic impact on society [7,8,10].

Severe conflicts developed among electricity companies and with the regulator, accusations crossed all parties, including the government.

There has been much discussion on the causes of the crisis [4-12], and different arguments have been used, depending on who is expressing them, either thermal generators or hydro ones.

What is clear is that there was a total failure of the price system embedded in the regulation. It was not sufficient to neither cope with the crisis nor provide the right economic signals for agents to contribute to solve it. Prices to final consumers were totally immune to the crisis; nodal prices continued to reduce, as the effect of the arrival of natural gas to the country from Argentina had driven the building of several combined cycle plants. This implied that, in normal conditions, price reductions were projected into the future. Nodal prices reduced almost 40% from 1993 to 1998, and continued its decline (see Figure 2). While short-term marginal costs increased up to the cost on non-served energy, regulated consumers—which account for more than 60% of electricity utilization in the SIC—were making consumption decisions based on a long-term marginal cost of production, completely isolated from the true marginal production cost at the moment. This uncoupling between supply shortage and forced demand inelasticity in practice meant a failure of the price system.

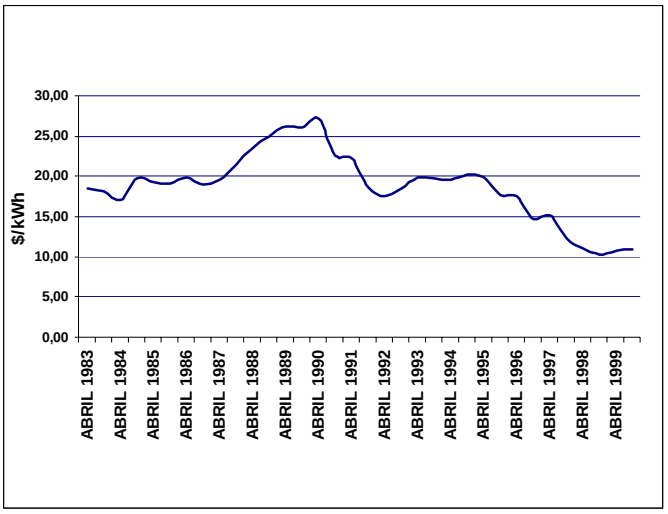

Figure 2: Evolution of nodal prices in the SIC
(Oct. 99 values)

When there are energy shortages, the spot price of energy becomes the cost on non-served energy (non-supply or outage cost), a value several times that of normal generation costs. For example, in October 2002 the non-supply cost, as determined by the regulator, was 12.4 times that of the regular energy cost (nodal price). The spot price in deficit conditions, the outage cost, according to the regulation, is to be used for exchanges among generators, giving deficit generators an incentive to reduce their shortfall. Deficit generators at the time of the crisis were essentially hydro ones, with contracts higher than their available energy. Nevertheless, since the first failure to supply in November 1998, deficit generators questioned that interpretation of the regulation, and did not agree to pay the outage cost. Under the law, the regulator had the power to intervene, by interpreting the regulation, one way or another, but it took long months to finally take a decision; much lobbying took place from all parties involved. It finally decided that the outage cost was to be used as the spot price for exchanges among generators.

The contract scheme and the compensation scheme did not work either. Generators failing to supply regulated consumers, through distribution companies, argued that because the drought was not in the statistics, it became a "force majeüre". The "insurance premium" paid did not cover that risk. Thus, without compensations, deficit generators did not have any incentives in looking for supply alternatives. Although generating companies had potential alternatives to cope with the crisis if the right prices had been in place [10], the lack of correct price signals, including compensation fines, slowed action, worsening impact on the companies themselves and the country as a whole.

V. SOLUTIONS TO THE CRISIS

The crisis demonstrated, dramatically, the difficulties of the political class to face emergency conditions in energy supply. Although the regulator had legal tools to manage the crisis by bringing spot prices closer to marginal costs, a slow response and ill thought solutions were taken to ensure supply and protect quality and security.

Instead of revising the price system with the intention to make it more flexible [9], a change of the law was hastened through Congress in June 1999, dramatically changing the 99 bis article. It eliminated droughts from the "force majeüre" conditions. The law now indicates that any generator, contracting at nodal prices with a distribution company that supplies final consumers, has to supply them, or compensate them at the outage cost, irrespective of the severity of an eventual drought. That places total risk responsibility on the generators, if they contract with distribution companies.

The change of law also gave the Superintendence of Electricity and Gas stronger powers to deal with crisis, and to impose higher penalty fines to agents that do not comply.

The hasty solution of changing the 99 bis article created new problems that later weakened the contract system, leaving distribution companies with no support to ensure future electricity supply. Contracts with distribution companies at the nodal price, transferred all risk to the generators, which started having second thoughts about contracting with them. Several years later, problems to sign contracts continue. There is one distribution company whose contracts ended, all of them, and it has not been able to sign new ones. As distributors cannot buy in the spot market, they are left with limited alternatives. In theory, non-contracted distribution companies have to be disconnected from the system, an unmanageable condition. The regulator intervened, and decreed that they must be supplied, irrespective if they have contracts or not. While this was a short-term solution that kept the lights on, it is out of the regulatory framework and at the end did not solve the problem. Investment in new generation came to a halt in the system. Only contracts with large consumers, out of the nodal price and full compensation scheme, are attractive to investors. Contracts with distribution companies are thought to be too risky, because of the full compensation scheme.

Four years after the crisis, the country is still looking for new regulations that will reduce the risk of non supply, and bring investment back into the country. A change of the law has been proposed by the government and is being discussed in Congress; critics argue it does not address the core of the problem, the price system that failed during the crisis.

VI. CONCLUSIONS

The crisis faced in the main Chilean power market in 1998-1999, and the changes introduced to the regulation due to that crisis, illustrate the difficulties faced when trying to assign supply responsibility through economic signals and regulator intervention in a complex market. The effectiveness of the Chilean regulation, that in many ways was a reference world wide, proved questionable in critical supply conditions. New regulation alternatives are still been searched, as of this writing, to ensure system expansion and quality and security of supply.

VII. REFERENCES

[1] Wood, A., Wollenberg, B.. "Power Generation, Operation, and Control", John Wiley, 1996.

[2] Bernstein, S., Agurto, R, “Use of outage cost for electricity pricing in Chile", Utilities Policy, 1992, pp. 299-302
[3] Serra, P., Fierro, G., “Outage costs in the Chilean industry.” Energy Economics, 1997, pp. 417-434.
[4] Rozas, P., “La crisis electrica en Chile: antecedentes para una evaluacion de la institucionalidad regulatoria”, CEPAL, December 1999
[5] Altomonte, H., Moguillansky, G., “La crisis electrica en Chile: ¿del modelo a imitar a principio de los noventa al modelo a evitar en el 2000?”, CEPAL, June 1999
[6] Fischer, R., Galetovic, A., “Regulatory governance and Chile’s 1998-1999 electricity shortage”, Economy Series, Number 84, July 2000, University of Chile.
[7] Diaz, C., Galetovic, A., Soto, R., “La crisis electrica de 1998-1999: causas, consecuencias y lecciones”, Estudios Públicos, vol 80, pp. 149-192, 2000.
[8] Chumacero, R.A., Paredes, R, Sanchez, J.M, “Regulacion para crisis de abastecimiento: leciones del racionamiento electrico en Chile”, Cuadernos de Economia, Year 37, Nº 111, August 2000, pp. 323-338
[9] Montero, J.P., Rudnick, H., "Precios electricos flexibles", Cuadernos de Economia, Year 38, Nº113, April 2001, pp. 91-109.
[10] Diaz, C., Galetovic, A., Soto, R., “Anatomia de una crisis electrica”, Revista de Análisis Economico, vol 16, No 1, pp. 1-49. June, 2001.
[11] Rudnick, H., Zolezzi, J., "Electric sector deregulation and restructuring in Latin America: lessons to be learnt and possible ways forward", IEEE Proceedings Generation, Transmission and Distribution, vo1. 48, 2001, 180-184.
[12] Rudnick, H., Montero, J.P., "Second Generation Electricity Reforms in Latin America and the California Paradigm", Journal of Industry, Competition and Trade 2 (1-2), June 2002, pp. 159-172

VIII. BIOGRAPHY

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Present and Future Approaches to Ensure Supply Adequacy in the Mexican Electricity Industry

Marcelino Madrigal, *Member*, *IEEE*, and Francisco de Rosenzweig

***Abstract*— This panel presentation will focus on how in Mexico the regulatory and legal changes have modified the way investment in generation is made. A brief introduction of the evolution of the Mexican electricity sector, supply responsibility and investment statistics on generation will be given. The presentation will also describe the restructuring options that are being considered to cope with the foreseen supply problems in the future.**

I. Introduction

Since its nationalization Since its nationalization in the 1960, the Mexican electricity industry is mainly conformed by an arrangement of two state-owned and vertically-integrated utilities named CFE (Comisión Federal de Electricidad) and LyFC (Luz y Fuerza del Centro). CFE´s responsibility is to perform all the activities necessary to generate, transmit and distribute electricity for all the public service costumers in the country, except for Mexico city and its huge metro area of neighboring sates, whose electricity distribution is perform by LyFC. Since the early 60´s to 1992 the electricity industry in Mexico remained fully vertically-integrated, state-owned and centrally planned, except for the natural private investments in self-supply and co-generation.

With the objective to decrease public investment in generation expansion, in 1992 the Electricity Law (Ley del Servicio Público de Energía Eléctrica) was modified by congress to allow new forms of private investments, since then, the electricity industry has cope with supply adequacy mainly with the use of long-term Power Purchase Agreements (PPA´s) that are awarded under a competitive bidding process carried out by CFE. Even tough for the next five years supply adequacy problems are not foreseen, the sustained growth of the Mexican economy in the last five years and the expected growth for the next ten, has brought to attention that supply adequacy needs be faced in a more efficient way. First, the PPA´s program may not be cost-sustainable in the long run; second, widely-generalized subsidies weaken the financial viability of the public utilities which restricts their capacity to invest in generation and complement the PPA program in the long run; and third, the need for public funds in social areas restrict government capacity to further invest in electricity generation.

The amalgam of factors above described has lead to an storm of proposals (in fact twelve as of December 2002) to restructure the Mexican electricity industry in order to handle in a more efficient way the foreseen supply adequacy problems and the financial viability of the public utilities in the long run. The presentation will describe the actual regulatory framework of supply adequacy, will present some statistics of generation investment under competitive PPA's since 1992, and will also describe the predictions for new supply requirements along with a description of the restructuring proposals, that are undergoing discussion at congress, with the objective to face such supply adequacy problems and other aspects related the long run sustainability of the electricity industry in Mexico.

II. Current Regulatory Framework and Supply Adequacy

The main institutions involved in assuring electricity supply adequacy in Mexico are: SENER (Secretaría de Energía – The Ministry of Energy), CFE (Comisión Federal de Electricidad – The largest public-owned vertically-integrated utility), and CRE (Comisión Reguladora de Energía – The Gas and Electricity Regulatory Commission). The Electricity Law (Ley del Servicio Público de Energía Eléctrica) establishes that CFE is the entity responsible of making all the generation, transmission and distribution expansion planning public-service activities of the Mexican electricity system. The energy ministry (SENER) in compliance with the finances ministry, is the entity that possess the final responsibility on authorizing the generation expansion plan included in the indicative planning performed by CFE, the ministry has to decide under which investment scheme the projects will be made.

If any of the generation investments project will be made by the private sector under the modalities introduced in the 1992 reforms (co-generation, self-supply, imports, exports and independent power producers), the investor has to get permission from the energy regulatory commission, CRE, to

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build and operate the generation project. The greater participation of private generation projects is in the modality of independent power producers, such projects, once the financing scheme is accepted by SENER, are awarded under a competitive bidding scheme run by CFE. The scheme awards the independent power producer whose proposed Power Purchase Agreement (PPA's) to CFE has the lowest leveled price for a contract of energy and associated capacity during twenty five years. Even tough the financing scheme of PPA's is supported by government funds and they have been then main driver for supply adequacy since the reforms of 1992, nowadays it is recognized by different groups that this scheme may not be cost-effective or the most efficient way to achieve long-run sustainability of the electricity sector given the expected increase in supply requirements and the need for public funds to invest on other basic social needs such as education and health.

III. The Last Ten Years of Investment Under Competitive PPA's

Since 1992 when the electricity law was modified by congress, to allow private independent producers to sell electricity under PPA's to CFE, the mayor capacity additions to the system have been made under this approach. Proportional to the 14,229 MW that have been added to the system in the period 1992-2002 (see Figure 2), approximately 42% has been made with public investment and 58% with private investment. From the total installed capacity in 2002, 20% is supplied by private participation, from which almost half (48.45 %) has been made under the competitive PPA's program, the rest corresponds to self-supply and co-generation projects.

IV. Supply Adequacy Challenges for the Next Ten Years

For the last five years demand growth has been around 5.2% in average. In Mexico demand growth is highly correlated to the Gross Domestic Product (GDP) as in most countries undergoing development; for the particular case of Mexico, demand has grown above the GDP.

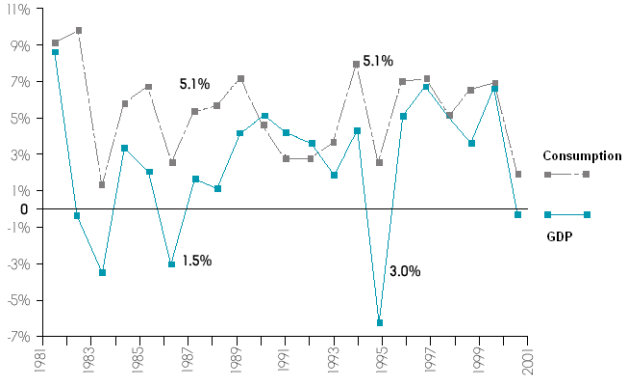

Fig. 1. Average growth of electricity consumption and GDP (SENER [1])

Figure 1 presents the historical growth of electricity consumption in Mexico, strong correlation with GDP can be seen.

For the next ten years it has been estimated that demand growth will keep in the same pace around 5.6% yearly. With these estimations, the associated required evolution of generation capacity for 2003-2011 in the Mexican electricity system is as shown in Figure 2.

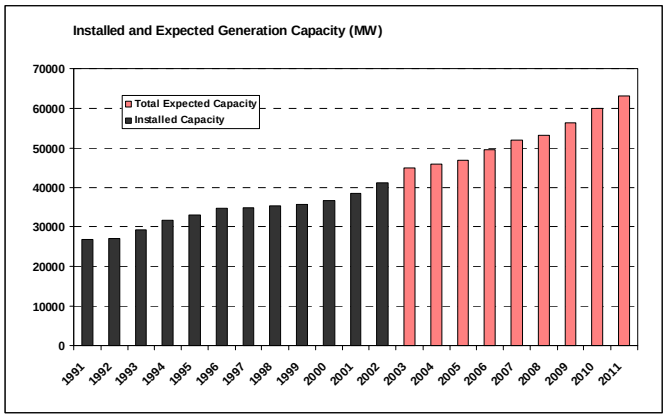

Fig. 2. Installed and expected generation capacity in the Mexican system (with data from SENER [1])

With the expected addition in Figure 2, it is estimated that the system reserve and operative reserve margins will improve above the low levels that were observed during 2001-2002, as can be seen in Figure 3.

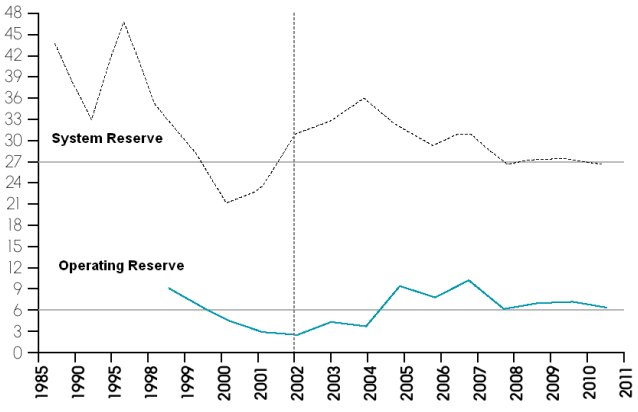

Fig. 3. Expected evolution of system and operative reserve margins (%, source SENER [1])

Around 7,534 MW of the required capacity for the next four years is already undergoing construction; 4,141 MW will begin the competitive bidding process most of them under PPA's programs with financial backup from the government and the remaining 14,636 MW that will be required by the end of 2011 are projects whose financing is still undefined. Figure 4 shows the predicted evolution of capacity for the period 2003 to 2011, and the status of the projects.

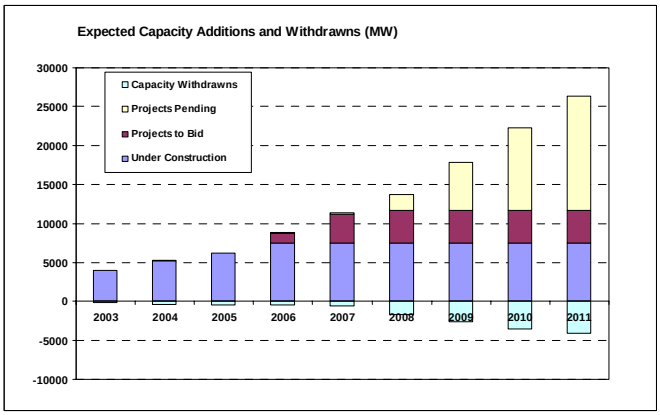

Fig. 4. Expected capacity additions and withdraws (With data from SENER [1])

The main questions to answer with the foreseen supply challenge after 2006-2007 is: should competitive PPA program continue to be the best lest-cost and most efficient way to guarantee supply adequacy in the Mexican electricity sector ?; should Mexico consider restructuring of its electricity sector to find better alternatives to face the supply adequacy and other investment requirements in the sector ?; should subsidies be revised and focused so that public companies can have better financial viability and therefore can better complement the investment required in the long term ?. Among this and other legal ingredients, that will be described in the presentation, has increased the interest to make propose alternatives to restructure the electricity sector in Mexico.

V. Restructuring Proposal to Cope With Supply Adequacy and Sustainability in the Long Run

Most of the political parties have submitted proposals to restructure the Mexican electricity industry with the purpose, among other issues, to face in a more efficient way the increasing needs for electricity supply of the Mexican economy. Early in 1999 the first restructuring proposal for the Mexican electricity sector was submitted by the government to the congress, the proposal came at a time where new innovative market designs where being proposed in the western states of the United Sates and other European countries; this first proposal planned the construction of an spot market as a means to obtain more government funds and attract investment. In that proposal the generation and distribution companies, after their privatization, would have competed for supply and demand of electricity.

The general consensus that something needs to be done with the electricity industry in Mexico to cope with the increasing supply needs has been so strong that up to December 2002 there are twelve different proposals to restructure the Mexican electricity sector. The spectrum of proposals, influenced by the challenge that the establishment of electricity markets has represented around the world (with their pros, but also more well-known failures) and the strong cultural background of public utilities in Mexico, has made the discussions over restructuring more of a political and philosophical debate, rather than a quantitative analysis of the needs and solutions for the supply and modernization needs of the industry. The proposals span from the privatization/electricity market solution to proposals that consider full vertical re-integration where possible of the public owned companies, changes in regulation and less private investment as possible. The talk will describe the structure, legal and regulatory framework that each of the proposals considers best suitable to cope with the foreseen problems of the Mexican electricity industry.

VI. Conclusions

Mexican electricity sector is still mostly conformed by two vertical-integrated state-owned companies, where central planning is made by the public companies under the approval of ministry of energy who guides all energy policy in the country. However, since the last reforms of 1992 the Mexican electricity system has principally relied on long-term competitive power purchase agreements with private investors as the means to face with the increasing supply needs in the last ten years. Such projects are awarded under a competitive bidding process where the private investor who offers the lowest leveled price of a twenty-five year contract for energy and capacity payments. The steady predicted growth of the Mexican economy and therefore electricity demand, has brought into attention that perhaps better least-cost and sustainable ways to cope with supply adequacy may be required.

Even tough in the next four-five years supply problems are not foreseen, the congress is involved in a discussion over restructuring the Mexican electricity sector since 1999. As of December 2002 there are twelve proposals for restructuring sector; these proposals differ one to each other and range from the two opposite views: the privatization and electricity market solution and the full vertical re-integration and regulation of the state owned companies with lest private participations as possible. It is expected that during 2003 congress will take a decision on restructuring the electricity industry, this will very much define if newer schemes to face supply adequacy will be considered.

VII. References

[1] Secretaría de Energía, *"Prospectiva del Sector Electrico 2002-2011"*, Mexico D.F. 2002, Available at: www.sener.gob.mx.

[2] Comisión Reguladora de Energía, *"Informe Anual 2001"*, Mexico D.F., 2001, Available at www.cre.gob.mx

[3] Comisión Federal de Electricidad, *"Desarrollo del Mercado Electrico 1997-2011"*, Mexico D.F 2002. Available at www.cfe.gob.mx.

[4] Mo Morgan Stanley, Equity Research Latin America, *"Power to Converge"*, January 27, 2003.

VIII. BIOGRAPHIES

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Francisco de Rosenzweig. Holds a Law degree from the Universidad Panamericana in Mexico City. He has more than seven years of experience in the public sector. He worked as executive assistant to the Director of the Legal Research Institute at the Universidad Nacional Autónoma de México (UNAM). In the Direction General of Public Credit at the Ministry of Finance Credit Public, he collaborated on the financial restructuring of concessioned toll highways. He held a position as International Associate at the firm Cleary, Gottlieb, Steen & Hamilton in New York City, where he took part in the legal framework for the restructuring, capitalization and modernization of PEMEX Petroquímica. Mr. Rosenzweig also participated in the public debt issuances of Mexico and PEMEX. Back in Mexico City, he joined the Ministry of Energy, where he participated in diverse interdisciplinary working groups focused on the analysis and promotion of schemes to finance and capitalize the energy sector. He is currently taking part in the design of the structural reform proposal for the Mexican electricity industry and in the North American Energy Working Group.

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