POWER SYSTEM PLANNING IN THE SOUTH AMERICA ELECTRIC MARKET RESTRUCTURING

Hugh Rudnick
Pontificia Universidad Católica de Chile
Casilla 306, Correo 22, Santiago, Chile
Phone 56-2-6864281 Fax 56-2-5522563
Email h.rudnick@ieee.org

Rodrigo Quinteros
Gener S.A.
Miraflores 222 - p. 4º, Santiago, Chile.
Phone 56-2-6868508 Fax 56-2-6868427
Email rquinter@gener.cl

Abstract The paper reports on the evolution of the planning function in the restructured electric markets in South America. It formulates the role of governments in infrastructure development and the required regulations in the energy field. It describes how the planning function is defined in the new electric regulations. It provides insights of the Chilean experience in indicative planning and how the private sector is defining power system expansion. Challenges in planning for all agents are summarised.

I INTRODUCTION

The basic infrastructure of a country is a key factor in its economic development [1]. The available infrastructure permits (or restricts) the provision of basic services such as energy, communications, transport, water, etc., central to the functioning of society. The quality and quantity of such services are conditioned by the characteristics of the corresponding infrastructures. In the fields of energy and transport, the development of basic infrastructure often implies the execution of a few macro projects, capital intensive, with high impact on the economic development of each country, and where their revenues depend on the local conditions and the development of future projects. Because of that, in the past States have often played a fundamental role in the planning, design and construction of such infrastructure. The objective has been to coordinate the development of the different projects so as to minimize the total social cost in a given time horizon. This was often the case in a context where the State played a monopolistic entrepreneurial role, independently developing basic infrastructure, occasionally with a limited contribution from the private sector.

That was the case in the electric energy industry in Latin America. However, new electric sector regulations reducing the role of the State were set in Chile in 1982, Argentina in 1992, Peru in 1993, Bolivia and Colombia in 1994, the Central American countries of Panama, El Salvador, Guatemala, Nicaragua, Costa Rica and Honduras in 1997. Brazil is also joining the group in 1998 and Venezuela and Ecuador have initiated actions. Essentially, all have introduced competition in the generation sector, withdrawing the State from what it used to be its role for many years, directly providing electricity through State owned companies. The planning function is also being reformulated.

The above has coupled to a global change where the size of the State is reduced and its role in society is reshaped. The State starts fulfilling a subsidiary role that transfers to the private sector the responsibility in the development of infrastructure; the State limits its action to situations where the private sector does not respond. This has arisen in part due to the difficulties faced by the States in funding the infrastructure expansion, thus concentrating their efforts almost exclusively on social matters, such as health and education. Diverse questions arise in those situations as to the role the government should play in the strategic design of the infrastructure. Answers are conditioned by the physical and economic characteristics of each service and its components; for example, answers are different for the electricity infrastructure than for the transport one. Both integrate different components (while the transport one includes airports, ports, public roads, railways, vehicles, etc., the electricity one includes generators, transmitters, distributors). These components interlink and their relative impact on the provision of the service is different. Some components present economies of scale or scope that require different handling by the State. Even more, these economies may condition different roles to the agents in the development of the infrastructure.

Having identified the role of the government, it is relevant to design the institutional arrangements to play that role, the instruments, and the required regulations. Relevant to this design is the growing globalisation and integration of economies, where infrastructure development interacts geographically and multinationally.

In many cases the State, while transferring the sector development to the private sector, has kept an indicative role to strategically orientate its evolution. The paper evaluates the way that role has been formulated in the electricity sector in Southamerica, and in particular, the results in the Chilean deregulation. The way the private sector has responded to the strategic interests as defined by the State is also assessed.

II PLANNING OF ENERGY INFRASTRUCTURE

There is a close relation between the energy consumption of a country and its economic development. Energy, in its various forms, is present as an intermediate resource in the production of goods and services, although the participation on their final prices is generally low. Energy is also fundamental on the quality of life of a nation and its people. Therefore, the lack of energy (or particular forms of energy) has an important negative impact in social and economic development. Therefore, governments often consider their central responsibility to create conditions such that the development of the energy infrastructure responds to the requirements of industry and population as a whole.

The energy infrastructure develops in several parallel subsystems that provide different energy products, e.g.

electricity, natural gas, oil and its derivatives, coal, fuelwood, nuclear energy, etc. These subsystems provide energy resources that compete with each other but also integrate chains of substitution and transformation. Markets of internationally tradeable goods (oil and derivatives, coal) coexist with other non-tradable (gas and electricity), but which may substitute each other, defining different requirements for the strategic design of the energy infrastructure. For tradable goods the State often limits its role to the definition of technical standards for infrastructure development. For non-tradable ones, particular to each national reality, the State has a central role to play either directly designing infrastructure or regulating the private role in monopolistic situations.

Each energy subsystem develops in two main fields, first in exploration and production, second in transport and distribution. Each stage has different technical-economic characteristics that may condition monopolistic treatment of the transport and distribution stages or competitive market treatment of the production one. This is the case for the electric energy. The generation stage is recognised as the one part of the chain where there are no significant economies or diseconomies of scale, and therefore a competition environment can be stimulated. However, given that storing electrical energy in industrial volumes is not technically feasible, electricity must be produced in the moment in which consumers require it. Southamerican countries chose to create independent coordination pools that do the physical system operation. They also chose to force the unrestricted generation markets into a competitive equilibrium clearing the market at the pool. On the other hand, neither electricity transmission nor distribution can be classified as perfectly competitive or contestable markets. The transmission stage presents indivisibilities and the existence of scale economies, while the distribution activity presents economies of scope, given the current conductor technologies. A re-regulation process has arisen, pretending to stimulate efficient behaviour of companies in those monopolistic activities.

Finally, the growing globalisation of the energetic markets and the electrical interconnections encompassing several countries outline other dimensions in the strategic design of the infrastructure.

2.1 Regulations for energy infrastructure

The regulation of the energetic infrastructure is conditioned by the natural and technological characteristics mentioned above. Activities coexist in each energetic chain that can developed under competition conditions while others configure as natural monopolies. Regulation must also recognise the growing interaction between the energy chains (for example between natural gas and electricity), the high degree of substitution and the need for a coherent global treatment. The indicated conditions necessarily outline different requirements to the State, that must seek to conciliate competition conditions with the necessary regulations and controls that lead to a social optimum. With this understanding the industrial organisation of the energy sector is redefined, in a new paradigm where the entrepreneurial State of the vertically integrated company withdraws. The State begins unavoidable to play a new regulatory and supervisory role, coupled to providing an indicative orientation of the strategic infrastructure design.

The most important regulatory functions that the State should develop are the following:

i) Creation of legal frameworks in the national and international level that permit the creation of multinational energetic infrastructures.

ii) Development of legal and regulatory mechanisms that facilitate competition in production, eliminating entry and exit barriers.

iii) Indicative planning and definition of global policies for development of the energetic infrastructure.

iv) Regulation of the monopolies and imperfect markets (transportation and distribution).

v) Regulation of externalities through adequate tariff systems.

vi) Definition, supervision and control of the quality of service

vii) Regulation of interactions between the energy offer and other sectors of the economy (provision of other public services, reduction of environmental impacts, etc.).

Finally, as a complement of its regulatory activity, the State can not avoid its social responsibility of providing an energy basic infrastructure, in order to assure minimal accessibility in all the national territory and equal opportunity to all the population to accede to the basic services.

The paper revises the way the indicative planning function is defined in the new Southamerican electricity regulations and how it has developed in the Chilean system.

III ELECTRIC INFRASTRUCTURE EXPANSION

The new regulations of the electrical sector in South America, coupled to the privatisation processes that have taken place, have transferred to the private sector the responsibility for expansion of the electric infrastructure [2], in a free market environment. The new industrial organisation models for the sector provide full freedom to private investors in generation. In Bolivia, Chile, Peru and Colombia an indicative expansion plan for the interconnected electrical systems, developed by a State entity, provides a minimal degree of coordination for investments in generation. This is done by the National Energy Secretary in Bolivia, the Ministry of Energy and Mines in Peru, the National Energy Commission in Chile and the Ministry of Mines and Energy in Colombia [3]. The plan carries more weight in the first three countries where it is also used to determine regulated tariffs. In theory, the State, given its subsidiary role [4], could act directly in developing generation plants that are socially required, but in practice, the private sector has been left to be the driving force.

Important differences appear in relation to transmission expansion, where there are different degrees of State intervention and coordination. In all cases, the private transmission owners must provide open access to competing generators. While in Chile a market approach leaves transmission expansion to private agents, through a negotiated open access tariff system; Argentina provides different coordinated modalities for system expansion, one of them with a market interaction among agents through a public bidding. In Bolivia, Colombia and Peru the State defines a transmission expansion plan and the resultant transmission tariffs. The Bolivian and Peruvian regulations are stricter in defining an adapted transmission system that sets a price cap for transmission payments. Only installations belonging to the adapted system are remunerated [5]. New lines can be built but they do not have guaranteed their incorporation to the adapted system.

IV THE CHILEAN EXPERIENCE

Even though in Chile there is full freedom for investment in the electrical sector, there exists a minimal degree of coordination for generation investments. The National Energy Commission (CNE) accomplishes this, through the elaboration of an indicative expansion plan for the country's two electrical systems.

The criterion used in the indicative planning consists of determining those options and project sequences, usually proposed by private investors, that minimise the costs of investment, operation and non served energy over a time horizon [6]. The solutions obtained around the optimum are then analyzed with minimising risk criteria, considering future demand growth and evolution of fuel prices. It is important to emphasize the indicative character of this planning since it does not compel the private sector to accomplish the determined investments.

In the elaboration of the expansion plans, there exists an instance in which the authority requests the private investors to submit projects they wish the authority to consider. Even though, this is not a requirement to develop an investment, companies have submitted projects, since the recommendation of the authority is considered favourable by some financial entities. In fact, for some investors in the generation sector, the indicative plan is important as a good source of information for the companies, while at the same time, a good support for raising funds from third parties. Nevertheless, differences arise between the perception that has the authority and the private investors of the expansion of the system. Such differences will be conditioned, among other reasons, by the capital costs, the demand forecast, the evolution of fuel prices and the discount rate.

From a private point of view, the investment decision will be to develop those projects that, with the tariffs and costs perceived by the private investors, produce desired return rates and/or respond to their strategic interests. In terms of the authority, the indicative plans are defined based on a social appraisal of fuel costs, investments and return rates dictated by the National Planning Ministry. The objective is to supply demand by minimising the cost to society.

Externalities also contribute to differences and make private decisions not to coincide with what is socially optimum for the country. In general, private investors do not perceive those externalities. In these cases and to fulfil its subsidiary role, the authority would have to provide adequate signals. Example of this is the requirement of environmental impact studies for generating plants. In any way, the authority must observe the emergence of distortions and provide the signals to the market to approach the social optimum, while letting the market forces act as freely as possible, since the existence of a competitive market in generation is recognised.

4.1 Importance of the indicative plan

The direct relationship between the optimum expansion of the electrical system and the regulated tariff levels determined by the authority, is a most relevant aspect of the indicative plan. The law indicates that every six months, the CNE must determine "nodal prices" for energy and capacity. This is done in agreement with a regular update of the indicative plan. The nodal prices represent the generation-transmission component of the final price to consumers smaller than 2 MW. It corresponds to a long-term projection (4 years) of the generation-transmission marginal costs. It is obtained through simulations of the stochastic hydrothermal operation of each system, considering the optimal system expansion as defined by the indicative plan.

The indicative plan is also relevant for the commercial agreements between generators and the unregulated market of consumers over 2 MW. It is a basis reference for negotiations of the supply contracts between generators and clients, to project the growth of the market and the possible investments in the sector.

From a financial point of view, the indicative plan is a good element to support requests for loans that the expansion projects require, since the recommendation of the authority is considered favourable by some banking entities.

Finally, the expansion plan permits investors to project the operation of the system, considering the price impact of a new generating unit and its impacts on profitability of investments. Though, as already indicated, it is probable that the expansion plans considered by private investors differ from those indicated by the authority.

4.2 Indicative planning and the real development

A review of the development of past investments in electrical generation in Chile demonstrates a growing divergence between the CNE indicative plan and the investments in fact accomplished by the private sector. Differences arise in the incorporation dates of new plants and/or in generation technologies used for the expansion. New plants are also introduced given new electricity or gas national and international interconnections, which are not considered in the authority indicative plans. The private sector is driving these interconnections in its search for competitive or strategic advantages.

The indicative plan provides a signal of the optimum future generation investments, from the social point of view, to supply demand. Until a few years ago, the signal was clearly reflected in the investment accomplished in the country. The indicative plan calculated by the CNE was quite adjusted to the reality. Nevertheless from 1993 this situation has inverted, so that it has been the indicative plan which has been adjusting to the investment plans of the private sector. The first indicia of this situation were observed when the private investors replaced the projects of coal-steam thermal conventional plants by natural gas combined cycle projects, something which only was taken into consideration by the authority as of 1995, when those projects were already in development.

The differences in the development of the investments in generation and transmission in Chile with respect to the planning of the authority [7] in large part have arisen because of to the arrival of a new technology: the natural gas combined cycle plants. The effect of this new form of generating electrical energy, more efficient than the technology conventional thermal plants, notoriously marked the end of the indicative character of the indicative plan. Though the CNE has updated that plan, changing its conception based on coal plants by one that only envisages natural gas plants, in the short term, another source of discrepancy has appeared with the private planning. The authority has not anticipated the apparent and unavoidable interconnections between systems, both at the domestic level as the international one.

The two interconnected systems in Chile are the Central Interconnected System and the Northern Interconnected System. The expansion of the natural gas based generation affected both systems, but their characteristics are quite different.

4.2.1 Central Interconnected System (SIC)

The SIC is a hydro thermal system, with predominance of the hydraulic component, that interconnects a total of 5267 MW, concentrating 81% of the total electrical power installed in the country and serving more than 90% of the national population. The demand growth is strongly vegetative and quite interrelated with the economic growth of the country; therefore as a rule there exists agreement between the demand forecast made by the authority and the private one. Nevertheless, the prediction of investments has not been close.

In effect, the SIC expansion plans have been drastically altered by the incorporation of natural gas combined cycle plants, mainly due to their low operation costs, that have implied dismissal of coal projects and even capital intensive hydroelectric projects. An example of this is observed upon comparing the CNE indicative plan of October 1994, that does not consider combined cycles in the long term, with that of October 1995 which only considers this type of technology for the thermal expansion of the system (Table 1).

The differences between the real investment plans and those proposed by the authority, impact the economic operation of the SIC and the prices of energy. However, this should not be relevant since, though it is considered a largely hydraulic system, its maximum regulation capacity is not greater than two years, minimal horizon for the construction of a combined cycle thermoelectric plant.

A comparison of the investment plans proposed by the authority and the real development of the SIC, indicates that the plan seems to be following the private investment projects, rather than viceversa. In fact, Figure 1 shows that though the 1989 plan was quite close concerning planned installed capacity with real one, the last indicative plans did not have validity beyond a year.

Surprisingly, given private decisions, an energy oversupply in the SIC is anticipated, given that the most important generating companies want to be present with efficient units in the future operation. This situation impacts in a gradual reduction of the energy price in parallel to important investments. This implies that investments in the SIC are not necessarily seeking a social optimum, only answering to the short-term interest of private companies or their strategic objectives. It must not be forgotten that most of the private companies of the electrical sector are involved in other markets, such as natural gas. Therefore, their investment decisions depend on a global optimisation of the decisions of each company in all the markets in which it participates, and not only of the electricity market.

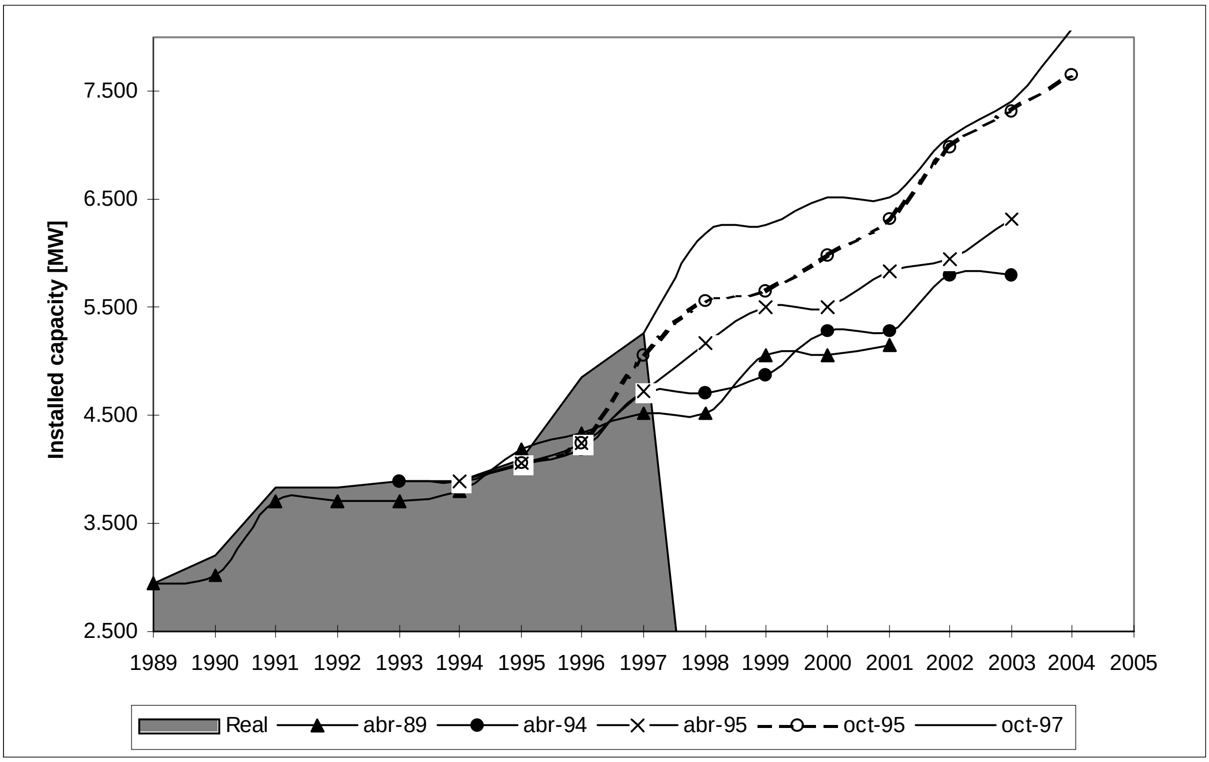

Figure 1 CNE indicative plans and real system evolution (SIC) [7]

4.2.2 Northern Interconnected System (SING)

The SING supplies fundamentally industrial and mining consumers in the extreme north of the country. The total capacity in the SING reached 1272 MW to the end of 1997, representing 19% of the total installed power in the country. 98% corresponds to thermal plants (steam-coal plants, gas turbines and diesel and heavy oil units).

The huge growth potential in the SING is given by large mining projects. Many times the size of one project justifies the incorporation of a whole generating plant. Therefore, the decision to build a plant is subject to the concretion of a mining project and viceversa. As in the SIC, the preferred expansion technology today is the natural gas combined cycle.

The SING, unlike the SIC, is supplied basically by thermoelectric units. There are no interannual reservoirs that establish a link between production costs from one year with respect to the following years. The demand forecasts and the long term system planning become irrelevant. Such is the case that the CNE indicative plan is presently made only for two years, so that any differences with the real developments do not impact short-term operation or spot prices.

Irrespective of that, as in the SIC, there exists an optimum expansion plan for the system adjusting supply to demand, that is not taking place. The future investments announced by the private sector project a high degree of over capacity coupled to high capital costs. Logically, the same over capacity produces an important reduction in prices and affects negatively the profits. This negative effect is driving private investors to negotiate possible alternatives to overcapacity, while searching to adjust to an optimum expansion plan. But the negotiations are not simple and before reaching agreements, another alternative has arisen: the interconnection between the SIC and the SING. Clearly this last alternative drastically modifies previous planning schemes that considered the systems separately. A single interconnected Chilean system with balanced hydrothermal characteristics may develop. Previous long term planning loses any validity.

4.3 The effect of the interconnections

National and international system interconnections are difficult to forecast and had not been considered in the regulator planning. In spite of that, private investors have incorporated this variable within their analysis of the future. Certainly the authority will add them as the investors develop them. It is important to indicate that the national or international interconnections could be accomplished through the construction of electric transmission lines or through the construction of gaspipes. In the case of an electrical interconnection the capital costs are smaller and energy exchange can be accomplished in both directions. Nevertheless the gaspipe interconnections may be attractive from a strategic point of view.

Clearly, the incorporation of the interconnection alternative makes any previous planning by the authority lose validity. Once again, the indicative plans follow the directions indicated by private investments and not these to the plan.

V CONCLUSIONS

Infrastructure development is crucial to growing economies. This is particularly the case for the energy infrastructure, particularly for electricity. The role of the State in stimulating investment in infrastructure has been redefined in the new market economies. The State remains as a regulator for monopolistic activities and as an indicative planner for competitive ones, like electricity generation.

In the electrical sector in Chile, the indicative plans are increasingly diverging from the real system evolution, given the increasing competition in generation. Investment decisions being taken by the private companies are not considering the same types of generating plants as the regulator or their commission dates. Commercial strategies of the private actors are the driving force in an increasingly competitive and dynamic market.

The indicative plans formulated by the authority have lost validity with the arrival of natural gas, combined cycle plants and national and international energy interconnections. The appearance of similar regulations and the development of market economies in the Southamerican region are stimulating these interconnections even further.

The importance of the indicative plan in Chile is no longer associated with the optimum system expansion. It still serves as the base for calculation of regulated prices, and also remains as a reference for negotiations between generators and large consumers. The only force that could couple real investments with the optimum planning would be the decreasing profitability of private expansion projects, resultant for overinvestment and reduction of energy prices.

The uncertainties faced in planning for all agents involved have clearly increased in this new environment. This is particularly challenging for the State, that needs to dare to assess new technologies and innovative investments, besides dealing with other traditional uncertainties [8], with the compelling responsibility of transmitting adequate signals to all participants. Investors face the same challenge, while aiming at increasing their profits, without a social responsibility but one with their shareholders. While their individual objectives coincide in character with that of their competitors, they conflict in time and results. The need is to be constantly assessing the actions of their competitors, as all individual decisions will affect profits of all participants. In this environment, large consumers increase their negotiation power, as the number of suppliers increase. Uncertainties will drive them to sign contracts over shorter periods, including periodic price reassessments.

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BIOGRAPHIES

Hugh Rudnick was born in Santiago, Chile, and graduated as a civil electrical engineer from University of Chile, later obtaining his M.Sc. and Ph.D. from Victoria University of Manchester, UK. He is a professor of electrical engineering at the Catholic University of Chile. His research 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 and Venezuela.

Rodrigo Quinteros was born in Arica, Chile. He received his B.Sc. in Electrical Engineering from Catholic University of Chile and he is working for his M.Sc. at the same university. He works as a Research Annalist in the Commercial Department at Gener S.A. His research interests include power systems economic dispatch, electric market regulation, pricing models and related topics.

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	oct-94		***oct-95***		***oct-96***		***oct-97***	
Date	***Plant***	***MW***	***Plant***	***MW***	***Plant***	***MW***	***Plant***	***MW***
oct/1994	Aconcagua 2	72						
abr/1995	Capullo	11						
jul/1995	Guacolda 1 thermal	150						
jul/1996	San Ignacio	33	San Ignacio	33				
jul/1996	Diesel Gas turbine	50						
oct/1996	Guacolda 2 thermal	150	Guacolda 2 thermal	150				
abr/1997	Pangue	447	Pangue	447	Pangue	447		
oct/1997	Loma Alta	38	Loma Alta	38	Loma Alta	38	Combined Cycle I	359
may/1997			Combined Cycle I	332				
nov/1997					Combined Cycle I	359		
ene/1998			Combined Cycle II	332				
feb/1998					Petropower thermal	49	Petropower thermal	49
abr/1998			Peuchén	72				
may/1998					Combined Cycle II	351		
jul/1998							Combined Cycle II	351
oct/1998			Mampil	160	Combined Cycle III	370	Combined Cycle III	370
oct/1998					Rucúe	160	Rucúe	160
ene/1999	Thermal coal	400						
mar/1999					Peuchén	72		
abr/1999	Hydro plant 1	60	Rucúe	100				
abr/1999	Hydro plant 2	100						
jun/1999					Mampil	47		
oct/1999							Peuchén	72
ene/2000			Combined Cycle III	332				
abr/2000							Mampil	52
sep/2000							Cortaderal	195
ene/2001			Combined Cycle IV	332				
abr/2001	Hydro plant 3	520						
ene/2002			Los Cóndores	103				
abr/2002					Ralco	570	Ralco	570
oct/2002			Combined Cycle VI	332				
ene/2003					Combined Cycle IV	332	Combined Cycle IV	332
abr/2003			Combined Cycle VII	332				
ene/2004			Combined Cycle VIII	332	Combined Cycle V	332	Combined Cycle V	332
abr/2004	Thermal coal	400			Combined Cycle VI	332	Combined Cycle VI	332
ene/2005			Combined Cycle IX	332	Los Cóndores	103		
abr/2005					Combined Cycle VII	332	Combined Cycle VII	332
oct/2005			Combined Cycle X	332				

Table 1: Indicative plans determined by the National Energy Commission [7]
Unless indicated, installations identified with names correspond to hydroelectric plants.