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The changing role of the State in the expansion of electricity supply in Latin America

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Throughout the history of the electricity industry, regulatory reform has been driven by the pursuit of tools able to create conditions that would favour infrastructure investment and, generally, to surmount the obstacles that hinder system expansion. This article addresses the interaction between regulatory schemes and electric power generation investment, with a review of the changing role of the State in the expansion of electricity supply in Latin America. It contains a critical assessment of changes in the regulatory framework since the outset of electric power market reform, describing the successive approaches to regulation adopted in the last three decades. The aim of this analysis is to help identify the key factors underlying the evolution of energy policies and to contribute to the formulation of a prospective view of the direction this evolution may reasonably be expected to take.

Keywords: electricity markets; regulation; security of supply.

1 INTRODUCTION: THE PENDULUM

In the century and a third since its inception, the electricity industry has undergone a substantial number of structural and institutional changes. As a general rule, these changes and the specific solutions adopted in each country have fluctuated radically between the predominance of private initiative and the prevalence of public control. Current trends confirm moreover that this pendular movement has continued uninterruptedly into the twenty-first century.

Though motivations may differ in each specific case, the universal *leit motiv* in industry reform is the need to seek new regulatory models with which to channel the necessary strategic expansion of electric infrastructure in general and generation facilities in particular. In this context, the literature affords many excellent reviews of power system reform, in particular in developed countries (see Joskow, 2008, for example). A substantial number of studies have also been published on the industry in developing countries (Bacon and Besant-Jones, 2001; Jamasb, 2006). The present paper addresses the situation in Latin America, a resource-rich region with a variety of energy options (coal, gas, hydro, biomass, wind) unevenly distributed across the continent, whose electricity demand has grown by more than 5% annually in the last ten years. Some of the authors reviewing electric power system reform in the region have focused on a particular country, such as Sioshansi and Pfaffenberger (2006). Others have conducted a comparative analysis of several: Arango et al. (2006), for instance, compared developments in power markets in Brazil, Colombia, Chile and Argentina through 2004 by Arango et al. (2006) while Millán (2006) reviewed the situation in the entire region.

Contrary to what would be desired and needed in this region more than anywhere else, especially in the last few years, electric power system regulations have changed very quickly. The aim of this paper is to present an updated and complete regional analysis of the regulatory approaches

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adopted to attract new investment in generation (covering the entire range of countries, where any manner of market-like reform has been implemented or at least considered). The evolution of the regulatory framework from the outset of electric power market reform is critically assessed in a long-term security of supply context, highlighting the successive approaches to regulation adopted in the last three decades. Firstly, favouring investment in generation is shown to be the key driving force behind the major changes in energy policy. Secondly, an attempt is made to contribute to a prospective view of the direction that evolution may reasonably be expected to take, in light of regulatory developments in the past five years.

While the pendulum has swung between regulation and liberalisation in many markets, in Latin America it seems to be swinging towards regulation again before ever having reached full liberalisation. The following discussion of the basic aspects of these alternating scenarios aims to describe overall trends, in the full awareness that they may differ considerably from specific cases.

All developing countries require high investment to respond to a continuous increase in electricity demand, which is directly linked to economic growth. South America alone will need to invest about 70 billion US dollars in the power industry over the next ten years. Because electricity consumption per capita in South America is relatively small, the fact that growth there (5 % yearly, as mentioned above) broadly outstrips the rise in demand in industrialised countries is hardly surprising. In 2008, installed capacity in Latin America came to 270,000 MW, with Brazil accounting for 34 %, followed by Mexico with 19.5 %, Argentina with 12 % and Venezuela with 8 %, see Figure 1. Electricity systems in the region are often organised around hub and spoke models, with networks that are only thinly meshed and have very few, and mostly incipient, international interconnections. The region has a wealth of resources (hydro potential, oil and gas). Hydro generation, with a 52 % share of the total installed capacity (and 68 % of energy generation), is the predominant source in the region. Plants are often located at cascades spanning several river basins with varying hydrological patterns. Hydro generation's large share of the total results in a "clean" energy mix and provides "leverage" for other renewables with seasonal (e.g., biomass-fired cogeneration) or intermittent (wind) production patterns. Hydro reservoirs are used to compensate for the variability of wind power production and the seasonality of biomass energy production with no need for expensive and polluting thermal plants as backups. Natural gas is playing an increasing role in the region, which also benefits from cross-border electricity and gas interconnections.

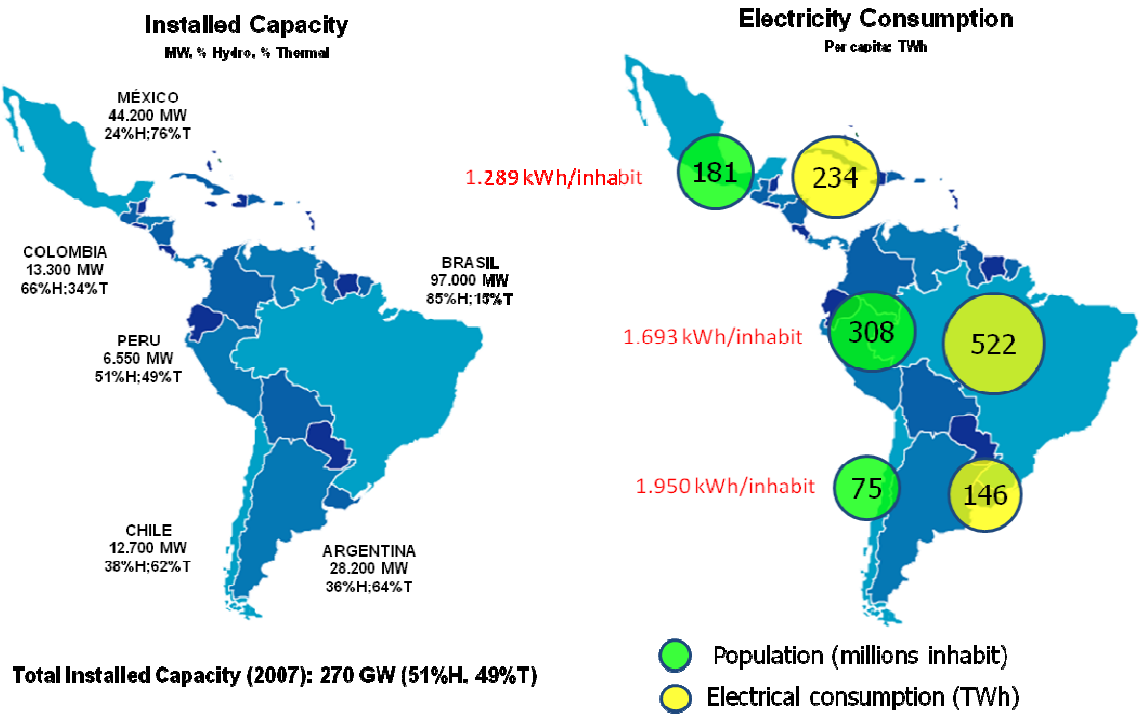

Figure 1. Installed capacity and electricity consumption in 2007.
Source: EIA, ECLA and regulatory agencies.

2 THE FORWARD SWING: STATE MONOPOLY

The electricity industry structures in place in the first third of the twentieth century were the result of the spontaneous growth of private companies, the descendants of the early electric power generation facilities that had supplied the major urban and industrial centres with electricity in the last quarter of the nineteenth century. Industry development stemmed from private initiative. The State, which regulated mining and hydraulic franchises with a light hand, played the role of observer in the electricity industry, which was subject to the same type of regulation as any other.

The State first began to intervene in rate-setting at around this time. Nonetheless, the change that was to affect the industry most significantly was the result of technology and economics: the institution of transmission grids (using alternating current, whereby energy could be carried across long distances) made it possible to build much larger power plants (mainly hydroelectric, far from demand centres), which in turn called for stronger companies and financial support from banks. These developments were reinforced by the Latin American financial crisis in the nineteen thirties and the waging of World War II in Europe, which weakened power companies' investment capacity, preventing them from undertaking the large projects needed to sustain the high pace of growth that followed.

The result was the first major restructuring of the electric power industry, namely nationalisation of the service in nearly all countries. Latin American States[1] in particular, embarked on ambitious

[1] The support provided by international financial institutions was instrumental to this process in Latin America (see Millán, 2006).

expansion plans focused on building large-scale, capital-intensive plants (mostly hydroelectric, but also a few nuclear facilities in Argentina and Mexico).

Electricity planning was, therefore, the responsibility of or at least heavily supervised by the State, which formulated the assumptions about fundamental variables (demand-side trends, fuel costs and so on) and established the target reserve margin, desired quality of service and so forth. The main idea was to optimise system performance, meeting estimated energy needs, while minimising production costs.

The nineteen fifties and sixties were characterised by investment euphoria, but the degeneration of the arrangements in place (with electric utilities becoming arms for political intervention in all areas: electoral interests, employment policies, inflation control) and the 1973 crisis (which stymied growth in the demand for electric power) very nearly bankrupted many countries' electricity systems. Governments had to intervene directly, pouring huge financial resources into the industry to prevent collapse[2].

But the problem did not end there. Many States had insufficient financial resources to undertake the new investment required to maintain service, and the sources of funding that up to that time had driven the relentless pace of investment began to demand deep structural change in return for financing. In many Latin American utilities, public management, with the State as regulator and owner, left much to be desired, while governmental intervention in business decisions bred inefficiencies. Moreover with the development of transmission grids, markets of a previously unthinkable size could be created.

This, in conjunction with the exhaustion of the economies of scale afforded by traditional generation (coal, fuel-oil, hydroelectric and nuclear) and the appearance of new technologies (gas-fired plants), paved the way for the expansion of electricity systems with marginal costs lower than the existing mean costs. At the same time, the main institutions providing financing in Latin America pressured governments into liberalising telecommunications, banking and energy services, inspired by similar reform underway in other countries, primarily the UK.

The resulting structural and institutional change consisted primarily of back-tracking, i.e., returning initiative to the private sector. Governments, in pursuit of a solution, resorted to Adam Smith's "invisible hand". This time, however, the pendulum was not to return to its point of origin, for in the new environment, the State often played a more active role in regulation and control.

3 THE BACKWARDS SWING: MARKET LIBERALISATION

In Europe, North America and Australia, industry restructuring and the introduction of competition were seen as an opportunity to reduce the State's presence (in keeping with the economic premises prevailing at the time), enhance industry efficiency to consumers' benefit and, in Europe, bring national regulatory provisions into line with the new integrated legislative

[2] Not all governmental investments proved to be mistaken. Brazil, for instance, which in the early nineteen seventies was growing by 11 % per year, was severely hit by the shock in oil prices, because at the time oil imports covered 80 % of domestic demand. To lessen the country's dependence on oil, the Brazilian Government introduced subsidies to develop ethanol from sugar-cane that remained in place until the mid-nineteen eighties. That prepared the ground for the subsequent entry of private capital in the industry, in which Brazil is the world's leading producer.

framework in Europe. Privatisation also generated public revenues and, at least temporarily, lowered rates due to the simultaneous effects of enhanced efficiency, the lower cost of new generating technologies and the significant decline in interest rates in the nineteen nineties.

In Latin American countries, in addition to seeking efficiency and reducing State interventionism, reform aimed to meet the pressing need to attract new sources of outside funding to enlarge and suitably manage electricity systems. With growing rates of economic development and the need to lighten governments' investment burden and role in industry expansion, such financing had become an imperative.

The chief characteristic of generation planning in a competitive environment is decentralisation: each company is responsible for its own investment decisions. But what mechanisms can attract the necessary investments? Initially, the solution to the problem was sought in the marginalist theory (Schweppe et al., 1988) applied to the electric power industry. According to this theory (obviously consistent with well-known microeconomic principles), the marginal market price, resulting from the relationship between supply and demand and defined to be the cost of supplying the system with one additional unit, is a suitable and sufficient indicator to attract investors. If the reserve margin narrows, prices, and consequently the incentive for new investments, rise.

Many European and Latin American electricity markets rest essentially on this principle. Nonetheless, beginning with the pioneer design implemented in Chile in 1982 (Bernstein, 1988), followed by Argentina (1992), Colombia (1995) and others, the regulatory frameworks adopted shared a common contradictory vision: an additional element was needed to ensure a suitable reserve margin (Pérez-Arriaga and Meseguer, 1997). This conviction inspired the design of mechanisms intended to supplement the incentives based only on the short-term price of energy: namely, capacity markets and payments.

- Such *capacity markets* were created to shield investment decisions from the adverse impact of a signal with a short-term component only. In order to minimise the risk aversion of potential standard and peak generation[3] investors by stabilising their revenues, the regulator obliged buyers (large-scale consumers, distributors, retailers and so on) to purchase and maintain sufficient firm generating capacity at all times to cover their maximum expected loads, plus a safety margin as defined in the regulations. As early as 1982, Chile had adopted a capacity market of sorts.

- *Capacity payments* aimed to solve the intrinsic problem in marginalist market design. Under this paradigm, the marginal system price (the cost of the most expensive unit producing at any given time) would enable all generators to recover their investment costs by capitalising on the difference between that price and their own marginal cost. For the highest cost producers –the peak generators, whose cost defines the price–, this difference is nil in most cases. However, this difference should enable investors to recover their investment in periods of scarcity, when

[3] In many Latin American electricity systems with a strong hydroelectric component, generators with such high operating costs are (presumably) only dispatched on the rare occasions when the reserve margin is very low (or even nil).

the market price would be defined by the value assigned by consumers to the absence of outages[4] or, more frequently, by a regulated price for unserved energy.

The problem lies in the fact that, firstly, such situations would seldom arise, constituting a risk not readily assumed by investors. Secondly, acceptance of this theory is tantamount to acknowledging that such situations will occur regularly in the future, an admission that regulators were unwilling to accept. Capacity payments were designed to compensate for this imbalance. These consist of additional, fixed and regulated remuneration paid to each generator, depending on its contribution to reliability (so-called "firm capacity"), therefore resulting in a reduction of the volatility of peak generator remuneration. At the same time, the regulator sought an effect similar to the effect of the reliability constraints in place in the former centralised planning models. In other words, the aim was to guarantee sufficient reliability by increasing the margin of installed firm generation capacity over expected demand. This margin would be greater than the margin that could be expected if the energy market were left to its own devices. Inspired by the Chilean approach, several countries in the region (Peru, Colombia, Panama, Argentina) implemented capacity payments (see Batlle and Rodilla, 2010).

With these supplements, the new model was expected to ensure the highest levels of efficiency for the system (as a result of competition among players) and optimal security of supply (thanks to the above additional mechanisms).

The initial results could hardly have been more promising. Investment rates were particularly high in the first two countries that launched in-depth reform of their electricity industries further to this model: Chile in 1981 and Argentina around ten years later (see Table i in Annex). Argentina, for example, which had appalling conditions prior to deregulation and privatisation, developed one of the most competitive generation markets worldwide. Thermal availability increased significantly in four years, while average monthly electricity prices on the wholesale market dropped by half and domestic consumption grew by 6 % yearly between 1992 and 2000. Distribution losses, energy theft included, were halved in just three years. Investment in the generation-transmission-distribution chain dropped by 70 %, tripling the productivity of money put into the system. Two private 1100-MW DC interconnectors were built to export electricity to Brazil. Oil and gas exports also rose. In 1994, the country ceased to need to import gas from Bolivia, and began to export power to Chile and Brazil (Rudnick, 2005).

More efficient maintenance, the upgrading or replacement of existing equipment and more sophisticated control systems for a tighter use of installations were all used to increase reliability and postpone further capital investment. The search for more efficient technologies in generation equipment, as well as cheaper energy resources, drove many private investors to build combined cycle gas units and pipe natural gas across national borders. South America soon had an international network of natural gas pipelines.

This experience served as a model for other countries in the region, the vast majority of which (the most prominent exceptions being Mexico and Venezuela) tried to implement the design in their own electricity systems.

[4] In hydroelectric systems with storage, the market price may be higher than the marginal price for any type of steam plant if future supply shortages are envisaged.

Unfortunately, in hindsight, the initial promise appears not to have materialised. The pace of investment was not nearly as brisk as needed and a number of sizeable difficulties appeared, in particular with respect to the security of supply. Trouble began in Chile in 1999, when the largest drought in a hundred years put market structures to the test, and due to the resulting shortage in electricity supply.

Similar conditions arose in Brazil: in 1996 the country implemented a market-oriented reform based on short-term marginal pricing. These prices were expected to attract new investments, but for a variety of reasons (extreme price volatility in particular) they failed to do so (see Table i in the Annex). The lack of new generation investments from 1998 to 2000 forced the country to use its hydro reservoirs at a more aggressive pace than usual. In 2001, when the main hydro regions were hit by a severe drought, the sole alternative was to ration energy consumption by 20 % for nine consecutive months, from June 2001 to February 2002. The Government's immediate reaction was to launch specific investment programmes to urgently attract new generation capacity. Subsidies were instituted in 2001 to encourage oil- and diesel-fired generation. About 2000 MW were installed in four years and the cost of this generation was passed on to consumers through specific charges. Likewise in 2001, new incentives were introduced to implement a programme to foster the construction of gas-fired plants that had been unsuccessfully launched in 1999. Special conditions were established for gas supply and power purchase agreements with distributors. A further 7000 MW were installed under this scheme. For more details, see Maurer et al. (2005). Once equilibrium was reached, the Government began to design the reform described in section 4 below.

The dry spell that lasted throughout 2004 in Peru exposed the country to a severe risk of rationing. By the end of that year, Argentina had its own energy supply problems[5] and cut electricity and gas exports to Chile and Brazil. That strained the Chilean market in 2006, when the limited supply of gas imports and a dry year almost forced it into rationing power.

Other more dramatic cases are still outstanding solution. The Dominican Republic, for instance, began the millennium with an annual rate of unserved energy of over 20% (around 10 TWh supplied, more than 2 TWh unserved[6]). The reason behind this scarcity is not strictly a lack of installed capacity, but the extremely high production costs of many of the generating units, considered as unaffordable for the system in most cases. This situation led to reform of the electric power system under the General Electricity Act adopted in 2001 and designed to attract foreign investors by introducing competition. However, high levels of institutional and regulatory uncertainty remained in place and are still far from being eliminated: generation-side system marginal prices and tariffs are permanently intervened. After a dramatic year 2004, in which unserved energy amounted to 4 TWh, in 2008 an additional 25 % of demand went unmet.

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[5] In 2001 Argentina underwent a severe political and economic crisis that led to intense government intervention, which included freezing gas and electricity prices and distorting the price of petroleum derivatives. Electricity and gas consumption skyrocketed as a result, while energy production investment stalled. Cancelling energy export contracts was the only way to secure the country's own energy supply. For a detailed discussion, see Haselip et al. (2010).

[6] Data from the Organismo Coordinador del Sistema Eléctrico Nacional Interconectado de la República Dominicana' website, www.oc.org.do.

A number of reasons can be found for such market malfunctioning in Latin America. The market design proved to contain many errors, in particular with respect to the mechanisms described above (Batlle and Pérez-Arriaga, 2008). On the one hand, capacity markets have become nearly superfluous, primarily because of the short terms involved, which provide scant guarantee for investments with significantly longer amortisation periods[7]. And on the other and more importantly implementing a regulated capacity payment entails enormous practical difficulties. Firstly, fair remuneration has been devilishly hard to determine. It has either been too small, failing to attract any generation investment at all, or has constituted an incentive for "undesirable" generators, leading in some systems to an excess supply of extremely expensive peak generation[8] (see Figure 2). And secondly, the methodology for assessing generators' true firm capacity has proved to be overly blunt and unable to identify their actual contribution to security of supply (fostering the entry of generators with scant availability in some cases).

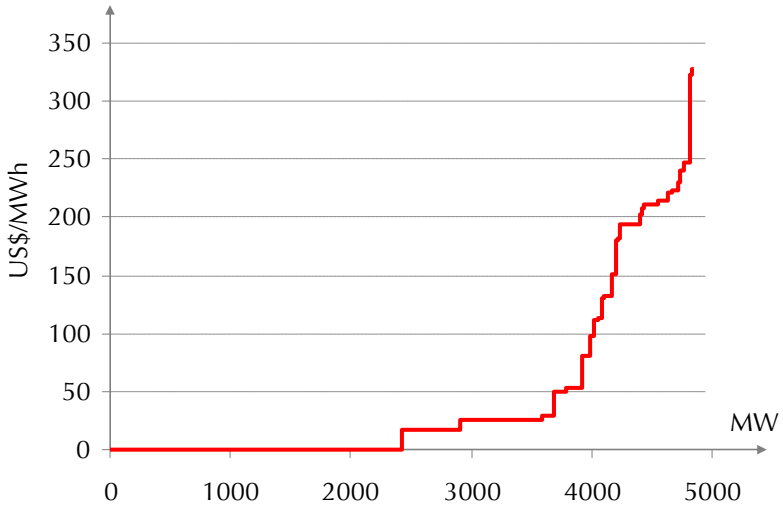

Figure 2. Peruvian electricity market supply function. December 2008.

In addition to flaws in design, the main threat to industry investment, however, is the weakening of institutions and the constant changes in the regulatory framework. The advanced and successful designs in place in the Argentinean and Colombian markets; the exemplary behaviour observed in the early years of Argentinean restructuring (prior to the 2001 economic crisis); Colombia's rigorous compliance with capacity payment commitments; and the long-term vision involved in the creation of regional markets in Central America or MERCOSUR have unfortunately been offset by short-term nationalisms that have been observed to emerge everywhere. Examples are to be found in the measures that threaten to neutralise Central America's Regional Electricity Market (MER) and governments' direct intervention and

[7] The duration of commitments proved to be too short despite the fact that, given the high country risk perceived by investors, the amortisation period demanded by equity investors was no longer than four years in many cases. By contrast, project financing structures required amortisation periods of over 10 years.

[8] In some countries, generation systems were chosen for their lower capital costs, which often meant installing high variable cost, low efficiency units. As a result, supply and demand are grossly "mismatched" in some systems, which has unfortunate consequences for the energy market (high prices) and security of supply.

concomitant rate-setting in certain markets[9]. Valid cross-border trade agreements have also been annulled with no other justification than the "national interest". The Argentinean crisis, in conjunction with the nationalisation of Bolivian gas fields by the party voted into power in 2006, made neighbouring countries acutely aware of the importance of the security of energy supply, and particularly of energy independence. More than just efficiency and suitable prices were at stake: it was a matter of actually having energy when needed.

Finally, key institutions such as regulating bodies and system and market operators are seldom wholly independent: of the government in power in the former and of market agents in the latter.

All these factors together revived mistrust among potential developers and financers, who perceived substantial risk and consequently either saw no point in investing or demanded high rates of return and short amortisation periods to offset the lack of any guarantee that they would recover their investments. As noted earlier, the security of electricity supply was threatened everywhere.

The most direct and tempting way to solve the problem, based on textbook market design, would be to recommend properly implemented marginal pricing theory in an attempt to correct all the flaws detected. As mentioned above, the reforms undertaken relied on the assumption that short-term marginal prices provide an optimal incentive for efficient operation and investment able to maximise overall system efficiency. Note, however, that this assumption is based on a number of simplifications, namely: generators' cost functions are convex; risk is neutral; no economies of scale or lumpy investments are present; and the market is perfectly competitive and information perfectly accessible. As pointed out by Rodilla and Batlle (2010), none of these assumptions comes even close to being realistic anywhere, but least of all in Latin American schemes.

In this context, after years of discussion, a certain consensus has been reached to the effect that pure marginalism does not work in real Latin American electric power systems[10]. Thus, the initial analysis mentioned above, which led to the implementation of additional security of supply (capacity) mechanisms when the original market designs first became operational, has not only been confirmed, but has in fact proven to be overly optimistic. The conclusion is that new mechanisms are needed to partially restore regulators' central planning role. This conclusion has given way to a second wave of reforms reviewed below.

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[9] Unfortunately, this is not limited to Latin American countries only: Spain's so-called "tariff deficit" (Pérez-Arriaga, 2005), France's "tartam" (MEFI, 2007) and the regulated price in Ontario (OEB, 2004) are examples of similar situations elsewhere.

[10] This conclusion is no longer applicable to Latin America only. Today, security of electricity supply is fast becoming a priority on electricity regulators' agendas, while this sort of intervention is being widely debated, considered and implemented. Indeed, Ofgem (2010) and CEER (2009) are consultation processes underway at this writing that illustrate the present importance of this concern.

4 THE NEW CHANGE OF DIRECTION: REFORM TAKES THE RETURN ROUTE

Fostering investment in new generation is a major challenge in markets such as Latin America's, characterised by sharply rising (and volatile) loads[11], where the entrance of new generation is vital for economic growth and competitiveness on the global market. Investors need to be shielded from the price volatility recorded in these countries' hydro-dominated spot markets by stable cash flows that enable them to borrow at lower rates to finance their projects.

Since the late nineteen nineties, regulators have been seeking initiatives to invigorate waning investment rates. Proposals for new mechanisms to ensure adequacy of supply appeared in Colombia as early as 1998 (Vázquez et al., 2002) and have been the subject of intense discussion ever since. The matter may in fact be addressed in two ways. One calls for some degree of backtracking, while the other entails a radical return to the traditional, centralised, cost-based model.

The most prevalent version of the former approach to date was first implemented in Brazil (see Barroso et al., 2006). After a series of proposals for legislative reform that failed to pass Parliament and the nine long months, when the country's power deficit climbed to 20 % of total demand, Brazil finally adopted Act no. 10848 in March 2004. A new mechanism, namely auctions for long-term energy supply contracts, was proposed as a solution to reconcile risk reduction for new investors with efficient energy procurement for regulated users, thus ensuring investment in generation.

The Brazilian electricity market design is based on two main premises. On the one hand, all consumers are required to apply for service for 100 % of their demand. And on the other, distributors, as "regulated retailers", must acquire the power needed to supply regulated users through publicly auctioned energy supply contracts (domestic consumers are not allowed to purchase power on the free market in any Latin American country). The approach adopted in Brazil pursues a dual objective: first, to ensure transparency in the procurement of electric power for regulated users, whereby the resulting price can be reflected in regulated tariffs (a similar philosophy is followed in the United States and Spain[12], to cite two examples); and second to facilitate the entry of new generation by offering very long-term supply contracts. Distribution companies define the load they are willing to cover in each auction[13] and, to spread the benefits of the economies of scale obtained with large hydro projects across the industry, a centralised procurement process is organised.

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[11] Electricity demand typically grows in Latin American countries at 5.5% rate per year, so installed capacity must nearly double every ten years.

[12] See www.bgs-auction.com in connection with the situation in the United States, and www.subastascesur.omel.es/frames/en/index.jsp with respect to Spain. Contract terms are no longer than one year in either.

[13] The Brazilian auctions provide distributors with several mechanisms to manage load growth uncertainty: over-procurement (3 % of load), volume reduction (i.e., put options sold by generators) and a series of consecutive auctions to manage energy delivery at different periods of time. For an in-depth description see Barroso (2006).

These Brazilian auctions tender forward contracts and energy call options, which must have physical backing, ensuring investors a source of stable revenues in the form of indexed prices that are unaffected by the uncertainty of the spot price. Such contracts aim to solve the problem of investor risk aversion through indexing, setting the price of grid tolls for the first ten years of operation, and especially by establishing long-term obligations (up to 30 years, with supply commitments falling due from three to five years after the auction).

In this framework, the regulator recovers certain former attributions, essentially as system planner. Its competencies include the establishment of auction procedures and general guidelines, including the terms of the contracts tendered (duration, price indexation, seasonal differences, options, etc.). Although all technologies compete in Brazilian auctions, the regulator has a backstop mechanism that allows the Government to hold specific energy auctions in keeping with energy policy decisions. Provision is made for technology- and project-specific auctions, which differ from the ordinary procedure primarily, in that the amount of demand auctioned is set by the Government. Technology-specific auctions were conducted in 2008 and 2009 for the purchase of 2 400 MW of bioelectricity (cogenerated power produced with sugar-cane biomass[14]) and 1800 MW of wind power (Porrua et al, 2010), respectively. Project-specific auctions have been used to ensure the economic feasibility of large-hydro plants located in the Amazon. The mechanism was used in December 2007 and May 2008 to tender the Santo Antonio and Jirau hydro plants (3150 MW each) at Río Madeira in the Amazon Jungle and in April 2010 to tender Belo Monte, an 11,233-MW hydro plant likewise in the Amazon.

This approach inspired reforms in a number of countries in the region: Chile's new "Short Act II", passed in 2005, provides for an energy tendering scheme less centralised than in Brazil (in which distribution companies design and manage their own auctions) and linked to shorter term contracts (from three to fifteen years). In Peru, the July 2006 Act to Ensure Efficient Electricity Generation, inspired by the Chilean approach, also envisages tendering as a tool for channelling regulated retailers' purchases, in which auction design is also left to distributors[15]. The Peruvian approach likewise provides for the use of technology-specific auctions as a backstop mechanism to foster specific sources. Colombia called its first "Reliability Charge" auction on 5 May 2008[16].

Brazil has now accumulated six years of auction experience and to date has successfully conducted a total of 31 auctions for existing and new energy, including auctions for renewable sources and large hydroelectric projects. From 2005, when the mandatory mechanism became operational, until April 2010, approximately 57 000 MW of new capacity were purchased for initial delivery as early as 2008 and as late as 2015, with terms of 15 to 30 years. This includes some 5 800 MW of

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[14] See Granville et al. (2008) for a description of recent regulatory changes designed to enhance the development of bioelectrical investments in Brazil.

[15] The first auction was called in October 2006. Five power distributors tendered part of their electricity supply to be furnished for a minimum of ten years, beginning in 2010.

[16] Under this mechanism, the auction product is the so-called "Firm Energy Obligation". Resolution CREG-071, Article 2, states that when the pool price exceeds the scarcity price, the "Firm Energy Obligation" is the obligation resulting from an auction or any similar mechanism, whereby a generator is bound to a certain daily output, determined on the grounds of ideal dispatch conditions, for as long as the obligation is in effect. As stated, this philosophy is in line with the proposals formulated by Vázquez et al. (2002) back in 1999, when the regulator was debating, for the first time, whether to replace or redesign the capacity payment mechanism in force in the Colombian electricity market at the time.

non-conventional renewable capacity and 17 500 MW from large-hydro plants in the Amazon. In all, over 35 power procurement auctions have been held in Brazil, Chile, Peru and Colombia.

A key question posed in these processes is whether or not the State should steer power expansion into specific generation technologies. When State-owned utilities prevailed in the region, centralised planning charted the course to be followed, initially opting, for instance, for large hydro development. The market approach adopted in the nineteen nineties was technology-neutral; the aim was to implement a clear set of rules on how income was to be earned and allow market agents (hopefully foreign private investors) to choose the most cost-effective technologies at their own risk. At most, governments would define non-compulsory expansion plans similar to the centralised plans of the past, but by way of indication only. As markets matured, those indicative plans (often non-existent) were often largely surpassed by reality. Competition between private and public participants has also been the object of intense debate. The behaviour of State-owned companies with respect to economic rationale has been a cause for concern ever since the auctions were designed in Brazil, and it remains a general concern worldwide. Investors have reservations about the low rates of return (hurdle rates) that are ultimately expected by the public sector. Such reservations are intensified by the fact that in some cases the auctioneer is the purchaser as well as the owner of these companies, which constitutes an obvious conflict of interests.

Technical neutrality has recently given way to government intervention and direct support of specific technologies, however. Chile has enacted legislation providing that all long-term contracts must include a clause, whereby 10 % of the power produced, excluding large hydro, must be derived from renewables. Brazil, in turn, has been using the backstop mechanism contained in its auction model to steer procurement towards specific sources. Under this scheme, demand is defined by the Government, which can thus avoid direct competition among different technologies. One of the ordinary energy auctions held in 2010, for instance, in which all technologies should presumably have been able to participate, was restricted to hydro plants. In addition, new technology-specific auctions were held for wind, small hydro and biomass. In the absence of due justification, Government coaxing to invest in specific technologies has a whiff of the old days of central planning.

Moreover shortcomings in the implementation of this scheme are giving rise to new regulatory problems in some cases. Where the unbundling of the distribution and generation businesses is incomplete or even non-existent and the wholesale generation market is highly concentrated, distributors can influence the outcome of these tenders substantially, as occurred in the Peruvian power market (see Batlle et al., 2009). Due to the decentralized auction scheme in place in Peru, distributors would be able to design auctions that would in effect constitute competitive mechanisms fostering vertical integration.

In other power systems, discussion is presently underway on changes of varying depth, ranging from reformulation of design to reform of the methodology used to determine firm capacity (Guatemala, Panama and Peru), and including calls for tenders along the lines described above (Guatemala and Panama, among others).

Argentina, one of the first countries to liberalise its electricity industry, has increased State participation in its electricity market since the 2001 economic crisis. In 2002, the Government created the Fund for Necessary Investments to Increase the Supply of Electric Power on the Wholesale Market (FONINVEMEM), a fiduciary fund (50 % participated by the Government itself and 50 % by the generation companies operating on the market) designed to finance two gas-

fired thermal plants. Later in 2004 the Government launched the state-owned company *Energía Argentina Sociedad Anónima* (ENARSA) whose corporate purpose includes, among others, the siting, development and operation of electric power plants. See Haselip and Potter (2010) for a detailed evaluation of Argentinean electricity industry reform.

As noted above, however, these are not the only regulatory reform movements in Latin America. A number of governments have opted for more radical restructuring, such as returning responsibility for mandatory centralised planning to the State (Ecuador)[17] or replacing bid-based with cost-based centralised dispatching (such as in El Salvador only recently[18]).

Other countries announced the intention to adopt a more market-oriented approach to regulation, but never actually did so. Venezuela, for instance, enacted an Electricity Service Act in 1999 that outlined the country's first-ever regulatory scheme, while at the same time opening the generation business to competition, among other measures. This reform never materialised (a second law, the Constitutional Act on Electricity Service, was passed just two years later). And in 2007, pursuant to the Decree on Reorganisation of the Electricity Industry, the electric power system was nationalised and the shares of the pre-existing private companies were transferred to the State-owned National Electricity Corporation (NEC) (see Peláez and Petzall, 2008). Retaining the centralised model did not guarantee either "adequate" or "sufficient" operation of the electricity system. The increase in installed capacity over the last ten years was negligible compared to the growth in energy demand (see Table i in Annex). In January 2010, an energy rationing plan was instituted which entails, among other measures, rolling four-hour outages every two days for domestic customers and 20% cutbacks for industrial consumers. The Government also announced an emergency plan to acquire fuel- and gasoil-fired plants to be in operation in two years' time.

All the foregoing is rendered more complex by the importance now attached to security of supply in the context of environmental impact (particularly climate change) in the definition of the industry's future technology mix. This calls for more active governmental participation.

In light of the above and coming back to the initial simile, the pendulum is still swinging between free market and regulatory intervention, between predominance of the private and the public sector. This constant pursuit of a more favourable environment to attract investment nevertheless creates greater regulatory instability than would be recommendable in a business with such long amortisation periods for investments. The narrowing amplitude of these fluctuations would, however, appear to leave room for the hope that a certain degree of stability will ultimately be attained.

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[17] On 23 July 2008, the Constitutional Assembly issued Constitutional Mandate no. 15 establishing the principle of a single nation-wide tariff and providing that investment in generation, transmission and distribution is to be made by the State, and charged to the national budget.

[18] The General Electricity Act passed in 1996 led to the implementation of a fairly bold market design (Millán, 2006). The reform was initially seen as a success, since foreign investors entered the system by acquiring both distribution and generation companies. However, the resulting wholesale market structure was overly concentrated and the regulator soon decided to intervene in a number of ways. In May 2003, the Salvadorian Government amended the General Electricity Act, providing that 'until such time as conditions guaranteeing healthy competition are in place, the Electricity Market (sic) will operate under a scheme based on marginal production, fixed and investment costs; and in the case of hydro plants, the price of water'. The "Regulations to Operate the Transmission System and the Wholesale Market based on Production Costs" was approved on October 2008.

5 CONCLUSIONS

Latin America is very diverse, as are its electric power systems. However, a review of the regulatory schemes in place in most Latin American countries in the late nineteen seventies shows that their regulations were extremely similar, regardless of whether the system was large or small, characterised by mostly hydro or thermal production, interconnected or otherwise. Regulatory movements in the region have swung back and forth like a pendulum, implementing energy policies that are positioned somewhere between State control and the free market.

In the early nineteen eighties, Chile designed a novel model that happened to be successful in the circumstances prevailing in the country at the time, and fifteen years later, this model was transposed to the rest of the region. In some countries, this entailed no more than "cutting and pasting" in a process that failed to pay due attention to the suitability of the standard design to each particular circumstance. In most cases the essential idea was correctly reflected in the new laws governing the electricity industry, which provided for opening electricity systems up to foreign investment via de-regulation and liberalisation, primarily of generation. While this may have been the right (and perhaps the only) option at the time, it has become fairly clear in the interim that the second level of regulatory design -the detailed rules and regulations- failed, mainly because they were not properly adapted to the conditions prevailing (not only in electrical, but also economic and social terms) in each country.

A similar process appears to be underway at this time, albeit on a smaller scale, in this case involving the transposition of the Brazilian model to other power systems. Although the Brazilian approach appears to effectively tackle the main problems detected in market-based systems, the risk of making the same mistakes is high if insufficient attention is paid to regulatory details. Another fact that should not be overlooked is that State intervention has not been negligible in Brazil's "market-based" auctions.

The degree to which generation and distribution has been unbundled is likewise important. The Brazilian power system is unique within the region, and not only because of its size, huge hydro potential and the country's current economic growth. In addition, its structure sets it apart from the rest, for neither generation nor distribution is overly concentrated and, more importantly, the two businesses are completely separate. Conditions differ substantially in other electricity systems in the region, particularly in countries where distributors organise and run their auctions to supply captive demand and to compete on the retail market for large consumers. As noted earlier, the result is a clearly undesirable regulatory situation, where, without the necessary unbundling, distributors conclude long-term contracts to supply regulated demand with generating units that may belong to their own holding company or group. This frequently leads to strife with the regulator, which tends to limit tariffs on no other grounds than its mistrust of the market and contract prices. If tariffs are set below market value, the resulting deficit erodes the financial health of the distribution companies and consequently the quality of supply. In addition, to retain large accounts, these distribution companies sometimes offer such consumers below-cost terms, which they are able to offset with cross-subsidies. In other cases distributors have resorted to persuading their customers that only they can assure satisfactory service quality or other advantages that only distribution grid companies can offer.

This situation must be thoroughly reviewed in the light of basic regulatory principles. Generation investors need some guarantee that the auctions terminating in long-term contracts with distributors are fair. This essentially means that the regulator should have complete control over

auction design (timing, product, quantity and reserve price, as appropriate) and execution. The State's role in auctions must be studied very carefully, however, particularly as regards the routine and insufficiently justified use of exceptional mechanisms (such as technology-specific auctions).

Other new and complex regulatory matters that exceed the scope of this article require careful analysis in this new context:

- On the wholesale generation market, the role of new generators whose income is partially or significantly hedged for many years (depending on the characteristics of long-term contracts) must be examined in terms of their coexistence with others whose income is linked to the short-term marginal market cost/price; and, on the demand side, a suitable pricing method must be designed to ensure both that the costs of long-term contracts are efficiently and transparently reflected in the tariff and that the signal emitted by the system marginal cost is duly perceived by regulated consumers to promote responsible consumption.
- In situations where regulated demand would have priority of supply in the event of scarcity (such as in Argentina), in order to avoid free-riding, non-regulated demand should have to participate in these auctions in some way since, as noted above, it also benefits from the entry of new (and hopefully more efficient and cheaper) generators in the system.

Finally, if the regulator deems that for social (or even humanitarian) reasons, some segment of the population must receive subsidised power, the resulting measures should be subject to well-defined, efficient and transparent procedures[19].

The re-steering of regulation toward more orthodox schemes should be a priority in most Latin American countries, with particular attention to the specific characteristics of each national power industry, since an efficient and reliable supply of electricity is imperative to the development of the region's huge economic potential.

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6 REFERENCES

Arango, S., I. Dyner, E. R. Larsen (2006). Lessons from deregulation: Understanding electricity markets in South America. Utilities Policy. vol. 14, pp. 196-207.

Bacon, R.W., J. Besant-Jones (2001). Global electric power reform: privatization and liberalization of the electric power industry in developing countries. Annual Review of Energy and Environment, vol. 26, num. 1, pp. 331-359, November 2001. Available at rru.worldbank.org/Documents/PapersLinks/567.pdf.

[19] The situation in Santo Domingo, Dominican Republic, exemplifies the consequences of inadequate regulation of subsidised tariffs. In some quarters of the city, all residents are heavily subsidised. Restaurants located in the wealthier areas of the city keep their freezers in these poor neighbourhoods, sending motorcycle couriers to fetch the cold goods as needed.

Barroso, L. A., B. Bezerra, J. Rosenblatt, A. Guimarães, M. V. Pereira (2006). "Auctions of Contracts and Energy Call Options to Ensure Supply Adequacy in the Second Stage of the Brazilian Power Sector Reform". IEEE PES General Meeting 2006, Montreal, Canada.

Batlle, C. and I. J. Pérez-Arriaga (2008). "Design criteria for implementing a capacity mechanism in deregulated electricity markets". Special issue on "Capacity Mechanisms in Imperfect Electricity Markets", Utilities Policy, vol. 16, iss. 3, pp. 184-193, September 2008. doi:10.1016/j.jup.2007.10.004.

Batlle, C., L. A. Barroso, M. Uribe (2009). "Long-term energy auctions design criteria and flaws in Latin America. The case of Peru". IIT Working Paper, Instituto de Investigación Tecnológica, Universidad Pontificia Comillas, Madrid.

Batlle, C. & P. Rodilla (2010). A critical assessment of the different approaches aimed to secure electricity generation supply. Energy Policy (2010), doi: 10.1016/j.enpol.2010.07.039.

Bernstein, S. (1988). "Competition, Marginal Cost Tariffs, and Spot Pricing in the Chilean Electric Power Sector". Energy Policy, vol. 16, iss. 4, pp. 369-3771. August 1988.

CEER (2009), "Generation Adequacy Treatment in Electricity. A CEER Call for Evidence", Ref: C09-ESS-05-03, Council of European Energy Regulators (CEER), December 2009.

CIER, Comisión de Integración Eléctrica Regional (2009). Síntesis informativa energética de los países de la CIER. Available at www.cier.org.uy.

Granville, S., P. Lino, F. Ralston, L. A. Barroso, M. V. Pereira (2009). Recent advances of sugarcane biomass cogeneration in Brazil. IEEE PES General Meeting, Calgary, July 2009.

Haselip, J. & C. Potter (2010). Post-neoliberal electricity market 're-reforms' in Argentina: Diverging from market prescriptions?. Energy Policy, vol. 38, pp. 1168–1176.

Jamasb, T. (2006). Between the State and Market: Electricity Sector Reform in Developing Countries. Utilities Policy, vol. 14, pp. 14-30, 2006.

Joskow, P. L. (2008). Lessons Learned from Electricity Market Liberalization. The Energy Journal, Special Issue on the Future of Electricity, vol. 29, pp. 9-42, 2008.

Maurer, L., J. Rosenblatt, M. V. Pereira (2005). Implementing Power Rationing in a Sensible Way: Lessons Learned and International Best Practices. ESMAP – World Bank, 2005.

MEFI, Ministère de l'Économie, des Finances et de l'Industrie (2007). Arrêté du 3 janvier 2007 fixant le niveau du tarif réglementé transitoire d'ajustement du marché. (In French) Journal officiel de la république française, Texte 11 sur 70, 5 janvier 2007. Available at http://www.industrie.gouv.fr/energie/electric/pdf/arrete-tarif-retour.pdf.

Millán, J. (2006). *Entre el Estado y el Mercado. Tres décadas de reformas en el sector eléctrico de América Latina* (in Spanish). Banco Interamericano de Desarrollo. 332 p. 2006, ISBN: 1597820288.

Ofgem (2010), "Project Discovery Options for delivering secure and sustainable energy supplies. Consultation document", Reference Number 16/10, Office of the Gas and Electricity Markets (Ofgem), February, 2010.

Ontario Energy Board (2004). Regulated Price Plan (RPP) - (RP-2004-0205). Available at www.oeb.gov.on.ca/OEB/Industry+Relations/OEB+Key+Initiatives/Regulated+Price+Plan.

Peláez, F. and P. Petzall (2008). Venezuela. In Electricity Regulation in 31 jurisdictions worldwide. Getting the Deal Through. Earle H O'Donnell Ed.

Pérez-Arriaga, I. J., C. Meseguer (1997). "Wholesale marginal prices in competitive generation markets". IEEE Transactions on Power Systems, vol. 12, no. 2, pp. 710-717.

Pérez-Arriaga, I. J., C. Batlle, M. Rivier (2006). "Diagnosis of the White Paper for the reform of the regulatory scheme of the power generation in Spain". IIT Working Paper IIT-06-041I, June 2006. Available at www.iit.upcomillas.es/batlle.

Porrua, F., B. Bezerra, L. A. Barroso, P. Lino, F. Ralston, M. V. Pereira (2010). Wind Power Insertion through Energy Auctions in Brazil". IEEE PES General Meeting. Minneapolis, Minnesota, US, July 2010.

Rodilla, P. & C. Batlle (2010). Security of electricity supply at the generation level: problem analysis. Working Paper IIT-10-027A, submitted to International Journal of Electrical Power and Energy Systems.

Rudnick, H.; Barroso, L.A.; Skerk, C.; Blanco, A. (2005), "South American reform lessons - twenty years of restructuring and reform in Argentina, Brazil, and Chile", IEEE Power & Energy Magazine, Volume 3, Issue 4, July-Aug. 2005, pp:49 - 59

Schweppe, F. C, M. C. Caramanis, R. D. Tabors and R. E. Bohn (1988). Spot pricing of electricity. ISBN 0-89838-260-2, Kluwer Academic Publishers, Boston, MA, 1988.

Sioshansi F. P. & W. Pfaffenberger (2006). Electricity Market Reform. An International Perspective. Elsevier Global Energy Policy and Economics Series. ISBN: 0-08-045030-X.

Vázquez, C., M. Rivier, I. J. Pérez-Arriaga (2002). "A market approach to long-term security of supply", IEEE Transactions on Power Systems 17 (2): 349 357.

7 ANNEX

The following table contains quantitative data illustrating the relationship between installed capacity and electricity demand over the last three decades in the most significant scenarios described in the paper. The table also lists the most significant regulatory events.

Table i. Installed capacity, electricity demand and regulatory highlights, 1980-2010[20]

		1980	1985	1990	1995	2000	2005	2008
Chile	MW	2195	3084	3372	5275	10371	12363	13673
	GWh	8658	16902	13851	25106	41269	52479	59704
		1982				**2004**	**2005**	
		Market reform				**Argentinean exports cut**	**Short Act II. Long-term auctions**	
Argentina	MW	10079	13476	14966	18511	26357	28292	30481
	GWh	35875	38870	45303	62809	88965	106523	121978
				1992		**2001**	**2002**	**2004**
				Market reform		**Economic crisis**	**FONINVEMEM**	**ENARSA**
Brazil	MW	28524	40515	49603	55497	67713	92865	102771
	GWh	129181	178247	211328	261060	324936	405100	459840
					1996	**2001**	**2002**	**2004**
					First reform: spot marginal pricing	**Rationing**	**Revitalization committe**	**New reform: LT auctions**
Colombia	MW	4475	6349	8312	10156	12581	13348	13868
	GWh	21454	25734	33877	41908	42296	50430	55378
					1995	**1998**	**2006**	**2008**
					Wholesale market	**Start of the capacity payment reform debate**	**Reliability Charge (RC) auction design**	**First RC auction**
Ecuador	MW	862	1623	1717	2465	3348	3567	4556
	GWh	3090	4524	6361	8405	10606	13404	18608
					1996			**2008**
					Electricity Industry Act			**Constitutional Mandate No. 15. State control**
Peru	MW	2037	2519	2842	3196	6070	6200	7158
	GWh	6795	8380	9558	13080	19923	25510	32443
				1994			**2006**	**2010**
				First reform: spot marginal pricing			**Act to Ensure Efficient Electricity Generation**	**First LT auction**
El Salvador	MW	499	703	703	962	11178	12358	1371
	GWh	1308	1538	1643	2779	3972	4254	4676
					1996	**2003**		**2008**
					General Electricity Act	**Amendment on the General Electricity Act**		**Regulations on operation based on production costs**
Venezuela	MW	7807	12453	18014	18161	21233	22910	23154
	GWh	33426	37988	56196	70672	89488	110370	119297
					1999	**2001**	**2007**	**2009**
					Electricity Service Law	**Constitutional Act on Electricity Service**	**National Electricity Corporation**	**Rationing**

[20] Data compiled from CIER (2009) and the US Energy International Administration, www.eia.doe.gov.