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Ensuring Resource Adequacy with Auctions of Options and Forward Contracts

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Abstract—The implementation of auctions of long-term firm energy call options and forward contracts as part of the instruments adopted in emerging countries to ensure resource adequacy is discussed. These mechanisms are being implemented in Latin American nations (Brazil, Chile, Peru, El Salvador & Panama) and fast-growing economies in Europe such as Turkey. Brazil has led this process and in overall has auctioned about 25,000 average MW of contracts, involving about 65 billion USD in financial transactions, while Chile has carried out its first auction in 2006, involving about 1,300 average MW (30% of energy sales of the main interconnected Chilean system expected for 2010). Overall, this mechanism is proving to be adequate to attract investments and ensure resource adequacy.

Index Terms-- Power system economics, power system planning, call options, firm energy, firm capacity.

I. INTRODUCTION

The need to ensure an efficient generation adequacy forms the backbone of electricity markets. This includes the establishment of correct incentives to allow the entrance of new generation in order to meet load growth.

A well-known result of competitive electricity markets is that, under marginal system pricing, short-term spot prices provide the correct economic signal for the entrance of new generation: an imbalance between supply and demand results in spot-price increases and thus creates incentives for the construction of new plants. Moreover, the optimal amount of capacity can recover total costs, i.e., expected spot market revenues are enough to remunerate investment and cover operation costs. While this may be conceptually efficient and the basis of the application of economic theory to electricity pricing, additional explicit capacity remuneration methods or capacity requirements (or obligations) tend to be imposed as additional mechanisms to ensure supply adequacy on liberalized electricity markets.

In this sense, this work discusses the implementation of an alternative scheme involving auctions of long-term call options and forward contracts as part of the instruments adopted in countries with emerging economies to ensure resource adequacy, such as Latin American countries (Brazil, Chile, Peru, El Salvador & Panama) and fast-growing economies in Europe as Turkey. Brazil has led this process and in overall has auctioned about 25,000 average MW of contracts, involving about 65 billion USD in financial transactions. Chile carried out its first auction on October 2006 trading about 1,300 average MW of contracts, involving about 7 billion USD¹. Other countries in the region are preparing the tender documents to carry out their auctions in 2007.

This work is organized as follows: Section II provides an overview of the international experience in energy market designs and resource adequacy requirements. Section III and IV discusses the specific challenges of emerging countries, presenting an overview of the proposed remedies to address resource adequacy. Section V analyzes the experiences of Brazil and Chile and Section VI describes some other countries that are adopting the same remedies.

II. BACKGROUND: INTERNATIONAL EXPERIENCE IN ENERGY MARKET DESIGNS AND RESOURCE ADEQUACY REQUIREMENTS

A. The basic market design

The early market designs, pioneered by Chile and UK, were centered on competition in the short-term market. The expectation was that, if the short-term prices were correct, all the other components would also be correct. In particular, there would be consistent signals for capacity expansion (in the UK, an explicit 'capacity adder' was included in the short term energy price in the form of a LOLP x VOLL uplift², while a capacity payment was introduced in Chile as a secondary product being supplied by generators). The logic was that if investors forecast an increase in short-term market prices, due for example to load increase, they would have an incentive to construct new capacity, and enter the system as merchant plants or by hedging part of their price risks with financial instruments, in particular forward contracts. Consistency would be assured because long term contract could be priced in relation to the futures market, where the prices are in turn projected from short-term market prices and expectations of future changes in supply/demand conditions.

Liquid, i.e. heavily traded, forward and futures markets (as

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¹ The amount only considers the energy component, as contracts also involve a capacity payment.

² Voll = value of lost load; LOLP = loss of load probability

those observed in the US) can potentially remove a large part of the uncertainty for investors, as they enable merchant power plants to sell their electricity for up to 5 years ahead at known forward prices. Even without longer term contracts (eg 10-15 year PPAs) they could in theory cover a significant part of their financing in the futures market.

B. The Difficulties

However, while the straight application of spot pricing theory may be conceptually efficient and the basis of the application of economic theory to electricity pricing in energy markets worldwide, international experience, however, leaves room for doubt whether price spikes in an energy-only market create sufficient incentives for new investment. This is compounded by the observation that most emerging countries do not have liquid futures markets and there are perceived risks of political/regulatory price capping of price spikes. In some countries, such as the UK, substantial capacity has been constructed after the market reform, and security of supply has up till now been adequate. Other countries such as Norway, Australia and New Zealand, are often mentioned as examples where no explicit measures for resource adequacy seemed to be necessary. These are some of the countries with the more developed forward/futures markets.

However, it has been argued that, even for those countries, resource adequacy is not clearly assured. For example, most of the new UK capacity was not built to meet load increase, but to replace older plants by gas-fired combined cycle plants. As a result, resource adequacy has been ensured by keeping the older plants as reserve. This may work in well developed economies, such as the UK and Nordic countries, with slow growing load (1-2% per year) but could not be replicated in fast-growing electricity sectors and economies such as Latin American countries or, for example, Turkey.

For example, Norway has not built any new capacity since its market reform in the early 90s, which suggests that the energy-only market has not yet shown whether it can assure security of supply. In addition, Norway faced a potential supply crisis in 2004, when inflows were very low and the risk of rationing, according to some estimates, exceeded 20%. For some critics, this high risk shows that the market system has not been able to induce the construction of required new capacity. Other analysts argue that the short-term price increase led to a load reduction which averted the potential crisis, thus showing that the market worked, and avoided unnecessary investments.

Finally, New Zealand has faced rationing and Australia seems to be concerned about supply security, as indicated by a recent IEA sponsored meeting on 'Saving Electricity in a Hurry' [1].

A recent survey sponsored by the World Bank reviewed the experiences of nineteen countries around the World, which had undergone reforms and had faced supply difficulties [2].

III. THE CHALLENGE OF EMERGING ECONOMIES

In the case of emerging economies, Latin America provides a good example of failures in the early resource adequacy requirements and a later correction, with the adoption of improved mechanisms.

The region is characterized by high demand growth rates (over 4-5% yearly) and strong hydro share (about 60%). In the '90s the region has been one of the world leaders in reforms coupled to private investments in the electricity sector [3]. Although differing in the degrees and details of implementation, the first "generation" of power sector reforms in the Latin American countries was based on market mechanisms, which formed the backbone of the regulatory frameworks to achieve the objectives of reliable and efficient guarantee of energy supply and adequate tariffs. In particular, the key driver for decisions was the spot prices in the shortterm market, coupled in some countries (Argentina, Chile and Peru) to capacity payments.

The accumulated experience so far has shown many positive aspects, such as a greater efficiency of the private utilities, the positive effect of the eligible consumers as market benchmark, lower consumer prices and the transparency brought by the regulatory agencies, which provide confidence for investors.

On the other hand, some important difficulties have appeared, in particular with respect to the security of supply (power crisis and rationings) in many countries of the region. A first reason for these supply difficulties is that the economical signal provided by the spot market is too volatile and difficult to predict to correctly indicate and stimulate the entrance of new capacity. This is especially true for the countries with a strong hydro-share, where the occurrence of conjuncture favorable hydro conditions can drive downwards the spot prices even if there are structural problems with supply. As an example, Fig. 1 shows the correlation between hydro conditions and spot prices in the Chilean electricity market.



Fig. 1: Hydro energy stored in reservoirs and monthly average of spot prices in the main interconnected Chilean system

It has also been observed that in hydro systems the spot price increases substantially only when the system is "too close" from a power crisis, when there is not time anymore to make investments. This pattern is shown in Fig. 2, which presents the evolution of spot prices and stored energy for the largest price zone in Brazil before, during and after the 2001-2002 energy supply crisis. As in the case of Chile, there is a negative correlation between prices and stored energy. In addition, notice that shortly before rationing started energy spot prices still did not reflect the scarcity of energy and after the rationing was over, prices immediately dropped to values close to 6 US\$/MWh and have been very low ever since.



Fig.2 - Recent short-run marginal costs (R\$/MWh) and storage levels

A second reason is the combination of a strong demand growth with a large volatility in the growth rates ("stop and go" economies that can be heavily affected by international crisis) and regional economic instability creating uncertain conditions for trading energy between neighboring countries. This makes the generation activity very risky and makes difficult the closing of "project finance" by the financing institutions for new projects, which ends up constraining the entrance of new capacity.

The capacity payments, adopted for example in Chile, add a stable component to project finance, but it only represents a minor part of the overall generator income.

In terms of resource adequacy requirements, we observe that, for countries with emerging economies, all previous aspects previously described in Section II also apply, but the fast (and uncertain) electricity load growth gathered with the need of long-term commitments to obtain financial loans (for greenfield generation) add an additional challenge for generation resource adequacy requirements.

IV. ENSURING RESOURCE ADEQUACY WITH AUCTIONS OF OPTIONS AND FORWARD CONTRACTS

As a consequence, several emerging economies have been adopting special mechanisms to stimulate the entrance of adequate capacity and ensure resource adequacy with a reliable supply. The core of these proposals lies in two main rules:

- a) The first rule is that all consumers, both regulated and free, should be 100% contracted;
- b) The second rule states that all contracts, which are financial instruments, should be covered by "firm

energy" or "firm capacity" certificates (FEC).

For the regulated users, the procurement of new capacity is carried out through public auctions. In one scheme, such as the one adopted in Brazil, the distribution companies (Discos) are required to inform their load forecasts and a contract auction is carried out to meet the total load increase. In an alternative scheme, such as the one adopted in Chile, Discos manage their own auctions, aggregating the demand of interested parties.

In overall, the advantage of the auction of contracts is to recognize that a Power Purchase Agreement (PPA) provides a degree of certainty in the generators' cash flow, thus allowing access to long-term financing and can be cost-competitive if procured through international competitive bidding (competition for the market).

V. FIRM CAPACITY AUCTION EXAMPLES: BRAZIL AND CHILE

A. The Brazilian Case

As described in detail in [4] the first rule in the Brazilian regulation is that all consumers, both regulated and free, should be 100% contracted. The contract coverage is verified ex-post, comparing the cumulative MWh consumed in the previous year with the cumulative MWh contracted. If the contracted energy is smaller than the consumed energy, the user pays a penalty related to the cost of building new capacity.

The second rule states that all contracts, which are financial instruments, should be covered by 'firm energy certificates' (FEC). For example, in order to sign a contract for 1000 average MW³, the generator or trader must show that it possesses firm energy certificates that add to the same amount. The FECs are tradable and can, along the duration of the contract, be replaced by other certificates; the only requirement is that the total firm energy of the certificates adds up to the contracted energy.

The FECs are issued by the Regulator for each generator in the system, and reflect their sustainable energy production capacity. For hydro plants, for example, the FEC corresponds to the (firm) energy production capacity in dry years. For thermal plants, the FEC is given by the available capacity (discounting average maintenance and forced outage rates), adjusted by a 'derating' factor that depends on the variable operating cost⁴.

The joint requirement of 100% coverage of loads by contracts and 100% coverage of contracts by firm energy certificates creates a link between load growth and construction of new capacity. For example, if an industrial

³ Average MW = GWh/#hours

⁴ The idea is that an expensive plant, for example, diesel-fired, is only dispatched late in a drought situation, whereas a cheaper plant, for example combined cycle natural gas, is dispatched earlier. As a consequence, the cheaper plant's contribution to the overall 'firm supply' is more significant than that of a more expensive plant. Taken at the extreme, a thermal plant whose variable operating cost was equal to the rationing cost would have a firm energy certificate of zero average MW.

user forecasts that its load will increase by 200 average MW three years from now, it will start to procure contracts, in order to avoid the penalties. If supply is tight, the traders will not have enough FEC to cover the contract; the only option will be to offer a contract for an investor to construct a new plant. In other words, the contract coverage requirement makes load growth the driver for the construction of new capacity, and the FEC coverage requirement ensures that the constructed capacity is adequate to cover this load growth.

For the regulated users, the procurement of new capacity is carried out through public auctions carried out every year. The distribution companies (Discos) are required to inform their load forecasts and a contract auction is carried out to meet the total load increase. The objective of the joint auction is to allow smaller Discos to benefit from economies of scale, for example of larger hydro generators. Each generator (Genco) that wins the auction signs separate bilateral contracts with each of the Discos, in proportion to their forecasted loads. This allows the benefit of cheaper energy to be shared by all consumers. Note that this contracting scheme is different from a traditional 'single buyer' scheme, where a government agency signs a PPA with an energy producer. In the contract auctions, there is no government interference or guarantee; the contracts are private instruments, signed between Discos and Gencos. Another important difference is that there is no government-based load forecast; Discos are responsible for this activity, thus avoiding the 'optimistic' government bias that in many countries has led to overcapacity and expensive PPAs.

In the case of auctions for new capacity, the country has used two contract types: standard financial forward contracts and energy call options, as proposed by [5, 6, 7]. In the Brazilian approach, suppliers are allowed to bid not only on the option premium but on the option strike price as well. The mechanism to compare options with different strikes and premiums, as well as the development of bidding strategies, is described in detail in [8].

Overall, since 2004 Brazil has auctioned some 25,000 average MW (firm energy, not peak capacity) among auctions for contract renewal and auctions for new capacity and involving about 65 billion USD in financial transactions.

A summary of the blocks contracted and weighted average resulting auction prices are depicted in Fig. 2 and 3.







B. The Chilean Case

In Chile, according to the previous regulatory model, the energy consumer price was calculated by the government every six months as a unique value which represented the expected marginal cost of generation and losses in transmission system. It was computed for each node of the interconnected system by means of penalty factors. However, the restrictions of natural gas imported from Argentina created an adequacy crisis in the electricity market (22% of the capacity of the main Chilean interconnected system corresponds to natural gas turbines), that weakened this price mechanism. Given the price formulation, it could not transmit adequately the increase of generation cost to the consumer price, producing a dramatic fall in generation investment.

Thus, as described in [9], a new regulatory model was implemented in the country, incorporating a real market signal in consumer prices by means of auction mechanisms. The old price calculation will fade out, as auctions replace existing contracts. The aim was to reflect generators and investors expectations about costs, allowing the existence of an attractive market with high yields. In addition, although each distributor must auction its own demand, the new law allows the accomplishment of a large auction, in which generators and new agents can make bids for the added demand of several distributors. As in the Brazilian case, the Chilean one obeys the rules described in section IV. Others characteristics of the Chilean electric auctions are:

• Distributors must be 100% contracted all the time, at least for the next 3 years.

• Distributors must contract their energy through auctions

• Auctions must be public, open, transparent and without discrimination.

• Several distributors can bid an auction for their aggregated demand.

• Each distributor must design and manage its own auction.

• Distributors can offer contracts for 15 years at a fixed price (indexed to changes in main variables).

• The government has the power to set a price cap.

Fixed capacity payments are offered.

• Auction winners will be the agents who bid the cheapest energy price alternative.

One of the most important aspects of the Chilean framework is that distributors design and manage their own auctions. This fact has opened a discussion about the incentives of the distributors to design a mechanism which will obtain lower final consumer prices. It is important to consider that contract prices are passed directly to the consumers by means of a pass-thought mechanism. Thus, distributors have a constant yield for their assets, irrespective of the results of the auctions.

Distributors auction their demand at any time, depending of the needs of each distributor. Although, distributors design their own auctions, the final mechanism designed must be approved by the government.

Generators must justify yearly to the National Energy Commission (NEC) their firm capacity to supply all the regulated contracted demand (unlike the firm energy used in Brazil, firm capacity is required in Chile). Generators can use a mix of existing plants and new ones to justify their capacity to supply. Thus, the general auction process is not divided into existing capacity and new capacity auctions as the Brazilian case.

The new regulatory model has a complex methodology to determinate the adequacy capacity (or firm capacity) of a plant:

- Firm capacity of hydroelectric plants is computed using the two driest historical hidrologies. Run of river plants and reservoir plants could present very different firm capacities for the same amount of nominal capacity.
- Firm capacity of thermal plants is computed using the available capacity, discounting average maintenance and considering force outage rates. Gas plants consider gas supply restrictions.

Finally, the new model considers contracts which will enter into operation, at least, in 3 years' time. It allows investors to obtain project finance and have enough time to build new plants. Hence, the new mechanism represents a business opportunity for new investors in the generation business.

Generators participating in the auctions compete by offering energy prices, which will be indexed during the contract period. Capacity prices will be defined by the NEC regulated price at the time of each auction, and fixed during the contract.

Overall, the first auction was carried out on October 2006, where about 1,300 average MW (30% of energy sales of the main interconnected Chilean system expected for 2010) was auctioned by the main Discos at 53 US\$/MWh in average, involving about 7 billion USD and supply contracts until 2024. No new agents made bids in the first auction process due to the short time given to prepare the offers. An important objective of future auction processes must be to allow the entrance of new investors to the Chilean electricity market.

VI. IMPLEMENTATION IN OTHER COUNTRIES

Overall, the new capacity auctions in Brazil and Chile have been of great interest to international investors looking to South America's energy market: candidate suppliers include a wide variety of technologies, comprising new hydro projects, gas, coal and oil-fired plants, sugarcane biomass and international interconnections.

The importance of these processes and their success in ensuring resource adequacy are driving other countries in Latin America to analyze and implement similar schemes. Among the countries involved, we can mention Peru, Panama, Ecuador and El Salvador. A general outlook of the region is shown in Fig. 4.



Fig. 4: Current situation in south and Central America

In the case of Europe, Turkey has recently proposed amendments in the Electricity Law to implement similar arrangements

VII. WHAT'S NEXT: ENVIRONMENTAL CONSTRAINTS

Among the issues that still need to be reviewed are the social and environmental constraints, which are an inherent part of electric markets and cannot be swept under the rug. As discussed in [10], the concern with the environment is absolute legitimate but in some cases has resulted in the construction of more expensive equipments this disrupting an efficient system expansion. The most fundamental challenge is to allow the society to know, through lively participation on the studies and licensing process of hydro and thermal plants, that there is no competitive energy without environmental impact. A policy of zero environmental impact has obviously a very high economic cost and the society must be aware about this tradeoff, so that the best choice to conciliate environment, economic growth and social justice can be chosen.

The rapid and hardly predictable changes in the sector, including national and international interconnections of the power and gas networks, strategic considerations by firms, availability of fuels and increasing public participation, make this a complex task.

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IX. BIOGRAPHIES

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