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REVIEW OF SUPPORT SCHEMES FOR RENEWABLE ENERGY SOURCES IN SOUTH AMERICA

C. Batlle* and L. A. Barroso**

1 INTRODUCTION

The South American region is among the most promising lands for the development of non-conventional renewable energy sources (RES, i.e. wind, small hydro, solar, tidal, geothermal and in some cases waste) or "green" energy worldwide. First, the region has a huge "green fuel" potential: strong and persistent wind flows, availability of biomass, potential for small hydro plants and significant solar power resources in some countries due to their weather characteristics and proximity of the equatorial zone, see Figure 1.

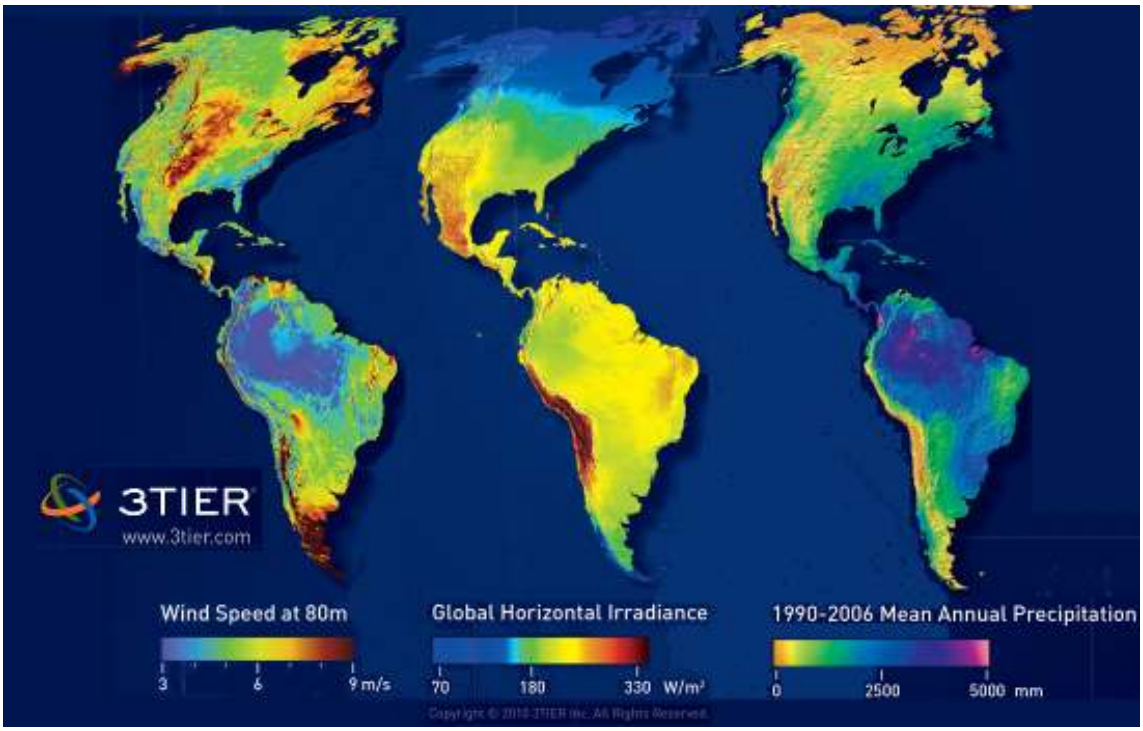

Figure 1. South American renewable potential © 3TIER

Second, it would be in many cases economically reasonable: not only from the worldwide carbon saving perspective (since it appears to be efficient to devote the funds coming from developed countries in deploying renewable resources in these areas), but also due to the fact that the cost of energy in some of the power systems is suffering a significant increase. Third, there are many isolated areas for which distributed generation is the best solution, both technically and

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economically. And finally, the high proportion of large-reservoir hydro plants in these systems provides a suitable environment for the deployment of these non-dispatchable RES[1].

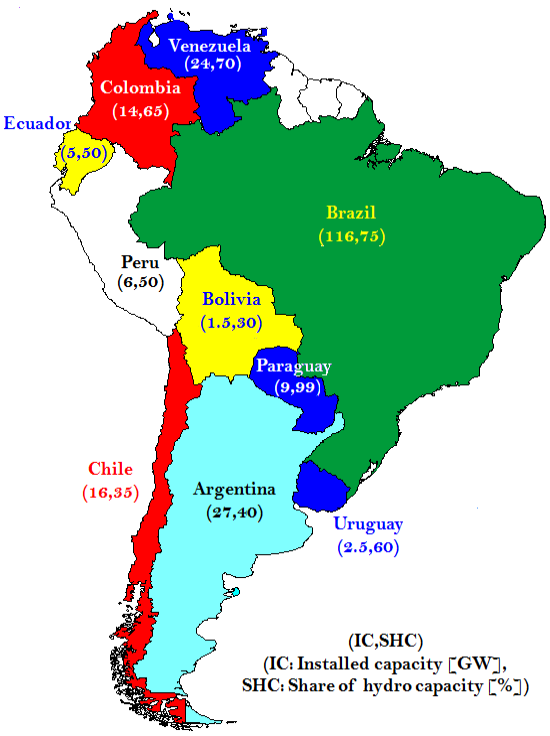

Figure 2. Installed capacity and hydro share and hydro potential in South American countries.

We already count on a very significant number of experiences and literature that can help us in assessing the efficiency of the different alternatives to promote RES. Nevertheless, many of the conclusions, particularly the ones extracted from the experiences in developed countries, cannot always be directly exported to the South American ones, since they differ not only due to their electricity industry physical characteristics (clean energy matrices with predominance of hydropower, and still a significant amount of untapped large hydro potential) but also to their regulatory characteristics - any of the countries has yet entered into any international climate change commitment and for instance most countries' regulatory framework has somehow returned to regulator-driven long-term contracting, see Batlle et al. (2010)- and to their specific socio-economic environment (country risk is still a big issue, financing is limited and the cost of power supply is major concern in the social and political agenda).

This article reviews the current experiences implemented to date in the region to promote RES. We briefly describe first the particular characteristics of the territory which make it so appealing for the RES deployment. Then we scour the continent examining the mechanisms implemented to date. We conclude by just pointing out what should be expected for the years to come.

2 PROS AND CONS OF RES IN THE SOUTH AMERICAN PERSPECTIVE

South America has one of the cleanest energy matrices in the world, mainly due to its intensive use of hydro power for electricity generation (see Figure 2 above) and more recently to the growing use of sugarcane ethanol for transportation in some countries.

While the "conventional" RES (mainly large hydro plants) already play a major role to provide clean electricity in the region, the penetration of non-conventional RES (wind, small hydro, solar, tidal, geothermal) is still small and it has occurred mostly through isolated initiatives of some countries but without setting clear targets for RES development. The primary objective of increasing the population's access to electricity associated to budget constraints have not allowed South American countries to set a priority for renewable electricity production for the past decade. This situation is, however, changing and renewable generation has started this decade with a significant penetration in some of these countries. The main reasons for the increasing interest for renewable are discussed below.

[1] Hydro reservoirs, available in most countries, can easily smooth out production fluctuations of intermittent (wind and solar) or seasonal energy sources (biomass or hydro), thus providing an operation flexibility that facilitates their technical and economic integration.

The energy power systems in the region present a number of particularities, which, if the costs of renewables keep on decreasing, can turn RES into an interesting generation option:

- From the security-of-supply perspective, RES provide the opportunity to diversify the current generation mix, currently heavily based on hydro facilities, resulting in power systems that are critically vulnerable to the El Niño/La Niña-Southern Oscillation.

  The lack of a coherent policy for environmental licensing and strong actions against reservoirs often leads to delays in the construction of conventional hydro plants, which might affect supply reliability. In contrast, renewable generation is usually spread out over several plants with smaller capacities, which provides a "portfolio" effect and thus a hedge against project delays.

  Also, RES construction time is short (about 18 months) in contrast to five years for "regular" hydro, at least. This allows flexibility in the entrance of new capacity; which is valuable as a hedge against the countries' load growth uncertainty[2]. RES are also the best solution to provide access to electricity to the large number of population that lives in isolated areas of the continent.

- From the economic perspective, the new "regular" hydro plants expected to be built in the years to come may in many cases be large scale projects (examples include the 11,233 MW Belo Monte plant in Brazil and the 2,400 MW Pescadero plant in Colombia, both under construction, and the large Peruvian hydro projects on the right-hand-side of the Andes, which can easily total over 6,000 MW[3]). Because of the large capital costs of this type of investments, the number of qualified investors expected to enter electricity markets in the region is limited, which somehow reduces competition. In contrast, due to their smaller scale RES increase the range of potential investors. Also, the substitution of imported oil- or gas- or coal-fired generation by locally available RES could save expenses in foreign currency and foster the installation of local manufacturers, increasing job creation and contributing to economic growth.

The downside of the renewable energies in South America is, in the first place, the higher economic cost as compared with conventional generation options (although the recent prices resulting from the long-term auctions in, for instance, Brazil or Peru indicate that, in some cases, that the gap is near to nil, see the next section). A second issue of concern is the need to reinforce the distribution and transmission networks.

3 RENEWABLE SUPPORT SCHEMES IN SOUTH AMERICA

RES energy support mechanisms have been present in the South American region for the past 10 years under the form of some sort of fiscal or tax incentive for renewable development in a state or municipality. In the beginning of the last decade Brazil, Argentina and Ecuador implemented feed-in tariffs to foster renewables. However, due to varied reasons, such incentives have not been successful (see below). The countries of South America also have never had binding renewable targets in their electricity matrices. Some isolated initiatives appeared at the beginning of the decade in some countries, but they were not binding.

With the implementation of the second wave of sector reforms from 2004 to attract new generation, see Batlle et al. (2010), long-term auctions for energy contracts or capacity payments (e.g. Brazil and

[2] Additionally, the lack of a coherent policy for environmental licensing often leads to delays of such large plants, therefore impacting on supply reliability. RES penetration is usually distributed over several plants with smaller capacities, providing a sort of hedge against project delays.

[3] Eastern Peru has a large hydro potential, enough to supply the whole country, export energy to its neighbours and to use its reservoirs to regulate downstream run of the river plants located in Brazil. Brazil and Peru are currently discussing commercial and scheduling arrangements to allow Peru to develop such projects, being Inambari (2,200 MW) the first hydro plant on the pipeline.

Colombia, respectively) gained momentum and started also to be used in several countries as their main (explicit) support scheme for RES from 2008. Auctions function as an indirect way for cost discovering, but they also manage to result in the right amount of investment and to reduce risk aversion with long-term contracting. This is the case of Brazil and Peru, where renewable auctions complement the regular auctions to attract conventional generation. Argentina and Uruguay have also implemented specific auction processes to attract RES. Chile has opted for a quota scheme placed on the generators. All other countries do not have an explicit support mechanism besides soft loans, tax credits, fiscal incentives or specific funds to foster RES investment in isolated areas, which are used everywhere.

Next we briefly review the current situation of RES regulation in the largest countries in the region.

Brazil

The "Proinfa" program, launched in 2002, was the first scheme adopted in Brazil to foster RES. It was essentially a feed-in tariff designed to contract until 2006 3,300 MW of wind, biomass and small hydro. Each RES had a different tariff and quotas of 1,100 MW. The energy produced by participating plants is purchased by Eletrobras (a holding company of power utilities owned by the Federal Government) through 20-year contracts, which then resells the energy to all consumers in proportion to actual consumption (formally a levy is paid). Consumers are then entitled to portions of Proinfa energy in their contract portfolios. The average price paid to Proinfa wind farms for 2010 is about 140 US$/MWh. Proinfa was responsible for the jumpstart of the wind industry in Brazil, but its completion has been delayed (the original deadline of 2006 was extended several times and is now 2011) and its performance has been criticized on grounds of (the lack of) economic signals for efficiency and for technological improvement as well as for the poor performance of the projects already operating under Proinfa contracts.

In 2007 a second support mechanism, now in the form of discounts on transmission and distribution tariffs for free consumers who purchase energy through contracts that are backed up by RES, was implemented. In practice, this is a cross subsidy on the 'wires' cost, paid by all captive consumers and received by the free consumers who purchase RES. Depending on the location of the consumer the benefit may be significant and it allows RES to sell high-priced energy contracts.

After suffering a country's power deficit up to 20 % of total demand for nine months in 2001, Brazil decided to change its market model. It took three years, but finally a new power sector regulation was adopted in March 2004. A new mechanism, consisting of auctions for long-term energy supply contracts, see Barroso et al. (2006), 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 contract 100 % of their demand with energy supply contracts (physically) backed by firm energy certificates. And on the other, distributors, as "regulated retailers", must acquire the power needed to supply regulated users through publicly auctioned energy supply contracts (competitive retailing for domestic consumers is not allowed in any Latin American country). Distributors are responsible for the load forecast that is sent to be auctioned, and penalties are applied to them if this forecast is wrong by more of 3%.

The traded products in the Brazilian auctions are forward contracts and energy call options, all of which must have physical backing, ensuring investors a source of stable revenues in the form of fixed-prices contracts (which in case of fossil generation are indexed to international fuel prices) that are unaffected by the uncertainty of the spot prices. Such contracts aim to solve the problem of investor risk aversion and ease financing conditions by establishing long-term obligations (up to 30 years, with supply commitments becoming active from three to five years after the auction).

In this framework, the regulator recovers certain former functions, essentially as system planner. His responsibilities include the establishment of auction procedures and general guidelines, including the terms of the contracts being tendered (duration, price indexation, seasonal differences, options, etc.). Although all technologies compete in Brazilian auctions, the Government may hold specific energy auctions in keeping with its 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. 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, also in the Amazon.

In the case of RES, the government has the prerogative to call an auction to contract a government-selected volume of RES, even if it is not contemplated in the demand forecasts prepared by the distribution companies, as well as to select the participant technologies. All consumers pay for this energy as a system charge. It works as a feed-in tariff scheme, but, as opposed to Proinfa, the consumers are not assigned a share of the contracted energy to his portfolio of contracts.

The auction-based approach has then become the main tool in Brazil to foster RES. Its "technology-specific" approach allows the organization of auctions to specifically contract one or another RES. The first auction was carried out in August 2008 to contract new energy from the cogeneration of sugarcane bagasse for delivery in 2011 and 2012. Some 2,400 MW (gross capacity) were acquired in 15-year contracts for an average price of 80 US$/MWh. The net capacity available for the power sector is about 1,500 MW.

In December 2009 a similar auction to contract wind power was carried out. The product that was offered to potential investors, a 20 year energy contract with delivery starting in 2012, has a very specific accounting mechanism designed to provide investors with a fixed payment (for financing purposes), while managing the quantity-price risk and incentivizing/penalizing production above/below a given energy threshold (see Porrua et al (2010)). 13,000 MW of wind projects registered for the auction, and some 1,800 MW of capacity were contracted for an average energy price of 77 US$/MWh (21% below the initial auction price). A diverse mix of investors (local and foreign private generators, manufactures and government-owned companies) won the contracts, and three new wind turbine factories are to be installed in the country. An impressive issue is the fact that the average capacity factor of winning projects is close to 45%. Another RES auction, now for a mix of technologies, was carried out in Brazil in August 2010, resulting in an additional capacity of 2,900 MW. This includes 70 wind farms, 12 sugarcane cogeneration plants, and seven small hydro plants. Wind energy totaled 2,050 MW at an average rate of US$75/MWh. Biomass came second with 713 MW of capacity at an average rate of US$82/MWh, and small hydro reached 132 MW at an average rate of US$81/MWh. Once more, the average capacity factor of winning wind power projects of the 2010 auctions is high: it approaches 45% with some of these projects presenting capacity factors over 50%. This has, of course, contributed to the low prices achieved but also raised fears if they are not overestimated, as the actual historical record of wind measurements in Brazil is quite small (1 or 2 years, on average).

Tax incentive programs have also been implemented, as well as direct subsidies to pre-investment assessments. A reduction of 75% on the income tax during the first 10 years of operation and special financing conditions were given in some regions of the country.

Chile

Chile has followed a different path than its neighbors. Distribution companies hold long-term energy contract auctions to supply their regulated consumers in which no technology discrimination is applied. In 2009 a wind farm won a 275 GWh/year 15-year energy contract for a price of

93 USD/MWh[4]. The electricity regulation was modified in 2008 and introduced a quota system, which determines that at least 10% of the energy traded by generators should be produced by RES. The requirement starts with a 5% obligation in January 2010 until 2014, and from then on there will be an increase of 0.5% annually until 10% will be reached in 2024. In case the requirement is not met, a fine of 28 US$/MWh is established. If the incompliance is repeated in a three year period, the fine becomes 42 US$/MWh.

It is uncertain if the quota-mechanism will be successful due to the (currently) limited number of RES projects readily available to be developed. In order to comply with these objectives, a strong volume of RES investment would have to take place over the next years. Mini hydro (hydro plants smaller than 20 MW), wind and biomass are the most economically attractive alternatives for the country.

The remuneration of such projects is also uncertain (the spot market or firm energy contracts with production-delivery risk are the alternatives) and some developers have asked for the implementation of feed-in tariffs or another RES support mechanism[5].

Argentina

The strong intervention in Argentina's electricity market after the 2001 political-economical crisis had multiple effects, including the stallment of generation investments and the freezing of commodity prices, which have contributed to an aggressive energy demand growth. With the increase of regulatory uncertainty, the drivers for new investments in generation clearly shifted, from the private sector (before the crisis) to the National Government (after the crisis).

For the past 5 years investment decisions have been conducted by means of long run energy contracts promoted and approved by the Government, with Cammesa (the wholesale electricity market administrator) as the final counterpart. This mechanism allowed Enarsa (the energy State-owned company created in 2004) to play an active role in the power market: Enarsa conducts auctions to contract stecific technologies and auction-derived contracts are signed between the winning generator and Enarsa. These contracts have guarantees of energy purchase and payment, which are given respectively by Cammesa and Enarsa. This has paved the way to some auctions organized by Enarsa to buy emergency (diesel) generation in 2007 and large thermal gas-fired power plants in 2009 and 2010.

In May 2009, Enarsa organized a sort-of auction specifically to develop renewable technologies, basically wind power (the so-called GENREN program). The renewable auction offered a 15 year contract. The total candidate supply offer was about 45% greater than demand. The auction awarded 895 MW of new capacity to be built in two years, of which 754 MW were wind power plants (the remaining 140 MW were distributed among biomass, geothermal, solar and plants burning biofuels). The price of the winning wind offers was about 130 US$/MWh, with capacity factors around 40%.

Uruguay

The Uruguayan government, by means of UTE (the national vertical integrated electricity utility) and after two successful auctions for low-scale wind projects (total 50 MW awarded) promoted an auction in 2010 to acquire 150 MW of wind power expected to come online by 2014 through 20 year contracts. Contracts are signed between the winning generators and UTE and a full set of

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[4] RES are entitled capacity payments in Chile. They amount about 9 US$/KW.month and are paid in proportion to the project's expected capacity factor de-rated by a factor of 30%.

[5] The investments that have materialized in Chile to date (and those under construction) have been developed by major incumbent generators using corporate finance, with guarantees of a parent company, and using particular opportunities that the market has given.

regulatory instruments were created by the Government allowing UTE to carry out such tender processes then pass the cost to consumers it serves. UTE received 950 MW of proposals from 22 projects of 15 companies for a 150 MW tender. The clearing rules of the auction were pretty complicated (for instance, projects with higher share of equipment components manufactured in the nation were favored and a two-round auction system was implemented, in such a way that first participants bid without transmission costs and on the basis of the results they had to rebid with such costs after a reference network was planned by UTE).

By the time of this writing UTE indicated its preference for the three cheapest bids at prices around 85 US$/MWh, but rivals allege that there are a number irregularities in some of the bids and threaten they might take legal action (Sciaudone, 2011). A new tender has already been announced for April 2011 to contract an additional 150 MW.

Peru

Peru has also adopted technology-specific contract auctions for RES according to the targets established by means of a RES development plan approved by the government. Although this plan has not yet been released, in February and July of 2010 procurement auctions were applied to contract small hydro, photovoltaic, wind and biomass generation. Winning generators were awarded contracts with distribution companies (to be passed-through to regulated consumers though) for up to 20 years to deliver the annual amount of energy offered at its offered price for 3 years ahead. As in the Brazilian case, demand pays a fixed annual amount and collects the spot market revenue.

About 140 MW of wind power were competitively contracted at energy prices averaging 80 US$/MWh. Contracting of 160 MW of small hydro, 90 MW of solar plants, and 27 MW of biomass was observed with prices about 60 US$/MWh, 220 US$/MWh and 63 US$/MWh respectively. These energy prices were 50% (biomass), 27% (wind) and 18% (solar and small hydro) lower than the auction price cap and winning investors were mostly foreign private companies.

Bolivia

Currently the Bolivian system is undergoing a strong restructuring process. Nationalizations have occurred in generation and distribution (it is not yet clear whether they will affect the whole system or not) and most developments are driven by the recreated state-owned vertically integrated company (ENDE).

The present tightness of the reserve margin is worrying, and the planned new generation investments are basically gas-fired. In the five-year expansion plan made by the system operator (CNDC) no development of RES is foreseen. The only hints about RES initiatives are some news about the presumed interest of ENDE to develop geothermal sources in the south of the country.

Ecuador

In Ecuador, RES activities have been small and sporadic. A law passed in 2000 established a feed-in tariff for photovoltaic installations (520US$/MWh) but, once implemented, it was never paid. Installations of some hundreds of isolated photovoltaic systems took place between 2003 and 2006 by means of a public fund (Marginal Rural and Urban Electrification Fund, Ferum) with funding coming from a 10% tax on the power consumption for commercial and industrial consumers.

Currently, the Rural Electrification Program for Amazonian homes (Perva) aims at installing PV systems of 200 W in 15,000 homes before 2013[6]. According to the estimations of the regulatory

[6] More than 2 million people in Ecuador out of a population of 15 million do not yet have access to electricity supply.

institution (CONELEC), a hydro plant of 1,5 GW (Coca Codo Sinclair, in the North of the Amazon) will be in operation on 2016 and 4 four additional GW will be installed before 2020.

In any case, the current regulation passed by President Correa has allowed the State to re-take full control of the electric power system and bans the private initiative from investing in generation facilities, which will definitely postpone any plans to foster RES developments.

Colombia

No explicit support mechanism for RES is in force in Colombia to date. On the contrary, a recent study published by the governmental UPME (Mining and Energy Planning Unit) clearly states that "at least during this decade, it is clear that reducing carbon emissions is not a priority that determines (at least significantly) investment goals". And even if this would be the case, large hydropower and also the rehabilitation of existing thermal plants are seen as the least-cost power options, also from the CO2 emission reduction point of view. The only advantage the government values of wind generation is, as it is for instance the case in Brazil, the observed production complementarity with hydro energy resources. But, at least for the moment, no explicit RES support mechanism is in place and the most likely way to hedge the system against this scarcity appears to be the expansion of the coal-based generation.

The only indirect support mechanism that can be detected in the regulation is that small hydro plants (up to 20 MW) are rewarded with a larger value of Firm Energy for the Reliability Charge[7] than other technologies (large hydro among them), what leads to a slightly larger capacity payments remuneration –the so-called Reliability Charge, see for instance Batlle & Rodilla (2010)-. On the contrary, in spite of the aforementioned complementarity with hydro production, wind generation does not have the right to perceive any capacity payment of any kind.

Venezuela

In Venezuela no RES support mechanism has been implemented to date. In 2007 the government created the National Registry of Renewable Energy. This registry is nothing but the first bureaucratic condition to supposedly be able to opt to join any potential (yet to come) program on RES promoted by the Ministry. In 2008 a National Pilot Plan on Wind Generation was announced, involving the construction of four wind parks, but the project appears to be delayed.

However, the new law passed at the end of 2010 establishes the "socialist management model", declares of public utility all the goods related to the electric power service and centralizes all the electricity activities in a fully State-owned vertical utility. The law announces a Development Plan of the National Electric Power System, which, among other objectives, will eventually contain 'actions aimed at promoting the use of alternative sources of energy, renewable and environmentally sustainable'.

Paraguay

99% of the generation capacity in Paraguay is large-hydro-based (Itaipú). There are no initiatives to undertake any initiative to deploy any alternative RES.

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[7] The Firm Energy for the Reliability Charge (Energía Firme para el Cargo por Confiabilidad or ENFICC) refers to the maximum electric energy that a generation plant is able to deliver on a continual basis during a year, in extreme conditions of hydro inflows. The capacity payment that generating plants are paid in Colombia on top of the wholesale market price -the Reliability Charge, see for instance Batlle & Rodilla (2010)- is directly correlated with this value.

4 CONCLUSION

Long-term auctions are the main tool to promote RES in South America. Auctions appear as an effective mechanism to stimulate competition between RES investors, to provide price disclosure while managing the right amount of investment and reducing reduce risk aversion with long-term contracting. On the other hand, its main challenges include the definition of criteria to select the quotas for each RES and the design criteria of a relevant set of guarantees (financial, technical and operational) in order to ensure projects will be actually built and deliver the expected performance in order to avoid the mixed experience with auctions to promote RES in other parts of the world. The attraction of competition remains an important goal to be achieved in order to foster competition in the auction.

The proof of the pudding will be in some years' time, when the winning projects of today's auctions will have to start delivering energy.

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