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A Paradigm Shift in the Commercialization of Paraguay's Surplus Electricity from Itaipu: From a Bilateral Agreement to Potential Entry into the Brazilian Electricity Market

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Abstract

Paraguay is a country with sustainable characteristics in terms of its power system, which is today 100% hydropower generation thanks to ITAIPU, YACYRETA, and ACARAY power plants. Paraguay has an energy export profile in the binational power plants, but this export (actually, energy cession) is restricted only to its partners (Brazil and Argentina) by the provisions of the respective bilateral treaties. These agreements also require the signing of power purchase contracts with the energy companies of the partner countries. The state-owned company, ANDE, is the Paraguayan part of these contracts. This work contributes to the analysis of the best options to harness the ANDE's power purchase from ITAIPU's Bi-National Hydropower Plant. The regulatory framework of this analysis is the regional and bilateral energy integration agreements, and the criteria to define the best options are the results of a financial evaluation of two hypothetical scenarios of energy surplus sales into the Brazilian short-term power market, based on historical data (2014-2017). The questions which guide this paper are: i) What are the options to commercialize 20 ITAIPU's Paraguayan energy under better conditions than the current ones? ii) How to improve the benefits of Paraguay's energy surplus? The cases of CAN and SIEPAC were analyzed to identify the mechanisms and degree of integration of their markets, and concerning the region, it was identified that both MERCOSUR and UNASUR do not propose the means to overcome the barriers to the commercialization of Paraguayan energy from ITAIPU in other markets in the region. An alternative was proposed in the Lula-Lugo Agreement (2009), which allows ANDE to gradually access the Brazilian electricity market. The results achieved in this study showed that the Paraguayan company can go from about USD 300 million to about USD 1,500 million in terms of income by installing an electricity marketer in Brazil (in the period analyzed).

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1. Introduction

The energy generated by the two huge Bi-national hydropower plants (ITAIPU and YACYRETA), owned – in equal conditions - by Paraguay and its border countries (Brazil and Argentina, respectively), allows this South American country to get the particular title of major hydropower exporter country of Latin America (OLADE). However, the export conditions are not of an integrated power market but based on bilateral treaties between partner countries – signed in 1973 to take advantage of shared hydraulic resources - which constrain the energy purchase exclusively to the signatory countries.

These bilateral agreements force the country with energy surplus to concede this surplus to its partner country. As a fact, it was defined an energy cession of the smaller power market (Paraguay) to Brazil and Argentina. Paraguay receives economic benefits for this energy cession (about USD 9/MWh).

Besides, the partner countries receive royalties for using the hydraulic resource (ITAIPU dam) or flooding part of the territory (YACYRETA reservoir). In Paraguay, these financial revenues represent the second position among the main sources of income for the Government, being these around 16% of the fiscal revenues of 2015 as can be seen in Fig. 1. This is a very particular characteristic of Paraguay in terms of

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economic and financial relevance for access to income from the use of natural resources for power generation.

The determination of the tariff and benefits for each condominium partner is restricted to the results of negotiations with the partner country and exclusive buyer of its energy, this could be said to represent a clear example of monopsony (is a market structure where there is only one buyer, therefore, this market is considered as imperfect competition). In the case of ITAIPU, the Treaty establishes that ELETROBRAS (or other Brazilian companies indicated by ELETROBRAS) has the rights of acquisition of the remaining Paraguayan energy (not used or not withdrawn) In the case of YACYRETA, the Paraguayan energy surplus can only be bought by EBISA.

In principle, the foregoing explains the possibilities of having access to possible greater financial benefits from the commercialization of Paraguayan energy in other markets, or the markets of partner countries, but under better commercialization conditions (out of the bilateral treaties) as it was analyzed by other scholars.[1,2] The problem raised by this research: are there possibilities of obtaining greater financial benefits (in comparison to the current restricted conditions) from the commercialization of Paraguayan energy? This paper seeks to contribute to the academic reflection on this question.

Although Paraguay is a partner of the two Bi-National hydropower projects mentioned above, for this study, to delimit the problem under investigation, it was decided to take exclusively the case of ITAIPU Bi-National.

Based on the foregoing, this paper proposes the general objective of contributing to the analysis of better options for the sale of Paraguayan energy from the ITAIPU Bi-National Hydropower Plant. This is a relevant subject not only for Paraguay but also to find out commercial mechanisms to foster regional power integration. Besides, the following specific objectives are established:

i. To recognize the possibilities of overcoming the restrictions established in the Treaty of ITAIPU regarding the availability of energy through Regional Energy Integration initiatives.

ii. Identity modalities for the sale of Paraguayan energy in the Brazilian power market according to current regulations.

iii. Carry out a comparative financial evaluation of the alternatives for the sale of Paraguayan energy in the Brazilian power market.

1.1 Paraguayan electricity sector

1.1.1 Development of the paraguayan electricity sector based on hydropower projects

Paraguay has a very particular energy matrix which has the highest rate of participation of hydro-energy in Latin America (99.8% electricity matrix), as can be seen in Fig. 2,[3] which shows that the block of the capacity of hydropower plants is 3.987 ktep of which only 1.599 ktep is used (situation due to the capacity of reservoirs and other factors, the remaining hydro energy is evacuated by landfills).

This context is due to its hydropower plants: ITAIPU, with 14000 MW of installed power, YACYRETA, with 3200 MW, and ACARAY, with 210 MW.[4] The state company in charge of the development of the electricity sector in Paraguay in the generation, transmission, distribution, and marketing segments is the "Administración Nacional de Electricidad" (ANDE), which has a vertically integrated business model. It should be noted that the same is the company that owns an exclusive public supply of electricity in the national territory by its law of creation (Law 966/64).[5]

ANDE currently has a total installed generation capacity of 8810 MW, a value that would not have a significant variation in the next 5 to 10 years.[6] On the other hand, demand growth has taken an accelerated pace as a result of the economic development of recent years; the projections of the

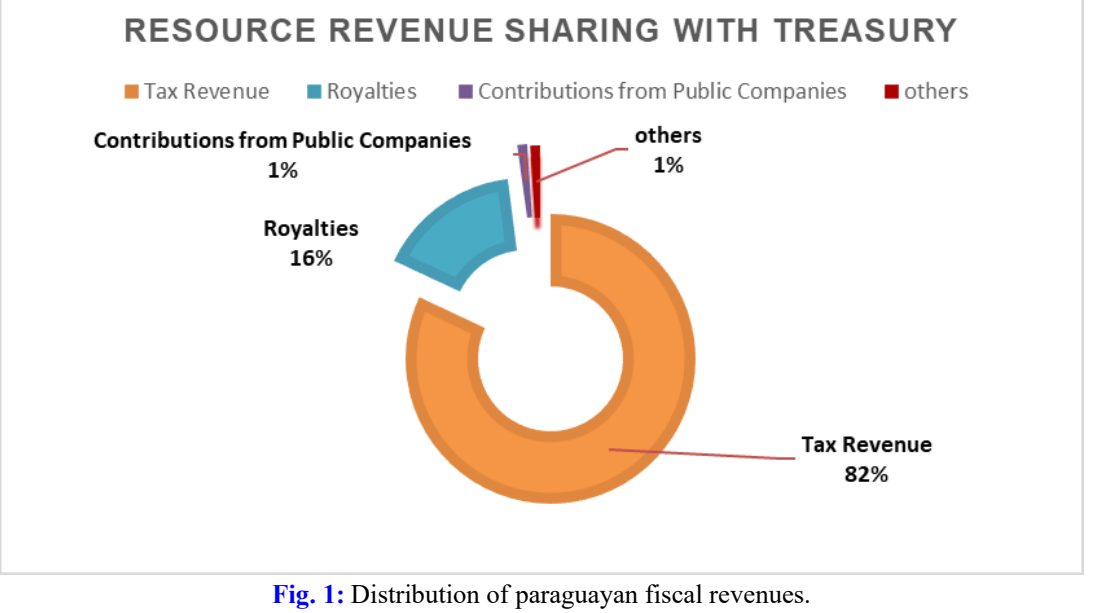

Fig. 1: Distribution of paraguayan fiscal revenues.

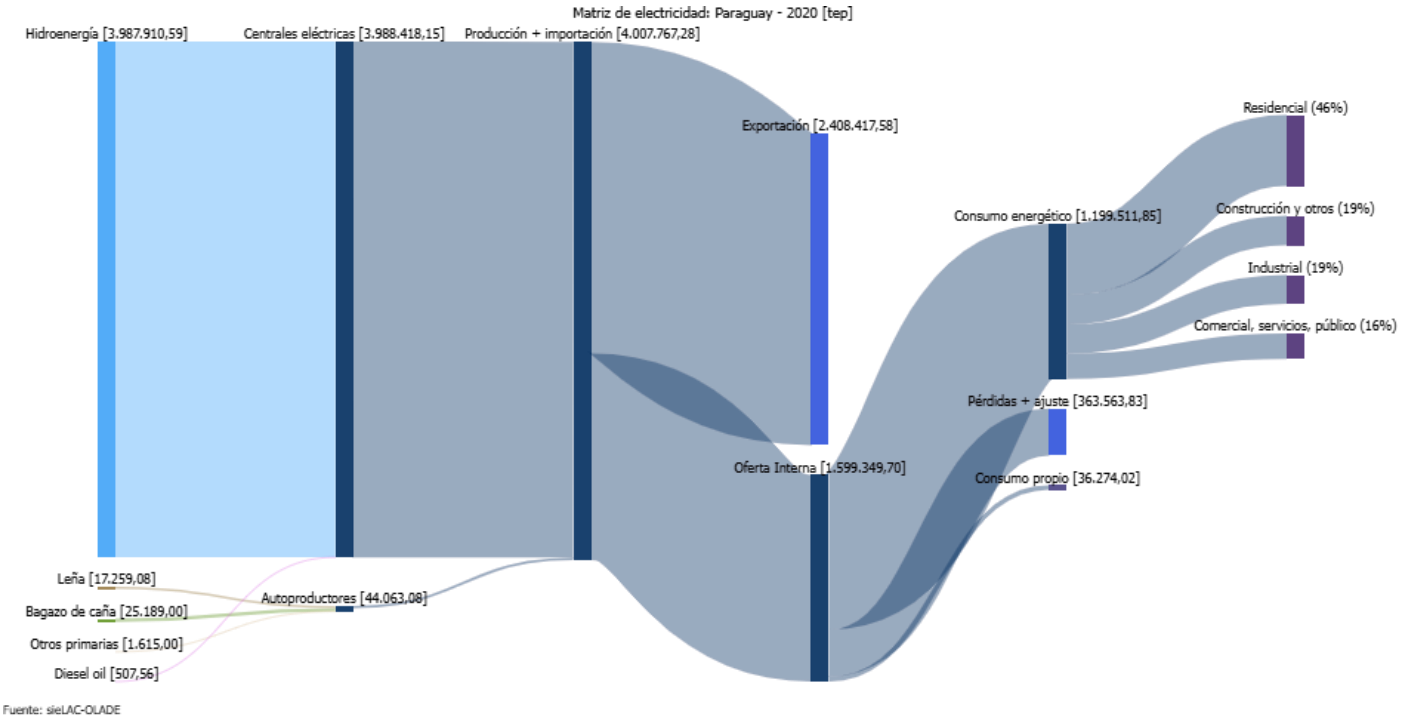

Fig. 2: Paraguay's 2020 electricity matrix.

Master Plan consider an 6.6% increase in maximum demand annually (see Fig. 3).[6] Reflecting on the last maximum demand registered in 2021 which was about 3.777 MW, it can be considered that Paraguay would have a potential surplus of electrical energy as highlighted that could be used in the best possible way to increase its benefits. Appendix presents earlier proposals, as precedents, to commercialize surplus electricity in Paraguay.[7]

Share of electricity production from the ITAIPU hydropower plant in Paraguay's demand is 85% (used as a base plant), this base plant condition would be constant according to ANDE's projection,[6] in which it is estimated that the projected dispatch from 2016 to 2025 could behave as shown in Fig. 4. The share of electricity production from the ITAIPU hydropower plant in Paraguay's demand is 85% (used as a base plant), this base plant condition would be constant according to ANDE's projection, in which it is estimated that the projected dispatch from 2021 to 2030 could behave as shown in Fig. 4.[6]

The expansion projects in the generation park, although Paraguay currently has a considerable reserve margin, have an expansion scenario that could reach some 11.833 MW (it should be clarified that the installed capacity values presented for Binational projects such as the expansion of YACYRETA, Corpus Cristi, and Itatí Itacorá would be divided equally among the partner countries), the execution of these projects would be long-term.[5] Reflecting on the surplus (excess) of electricity in Paraguay, the question arises of the possibility of

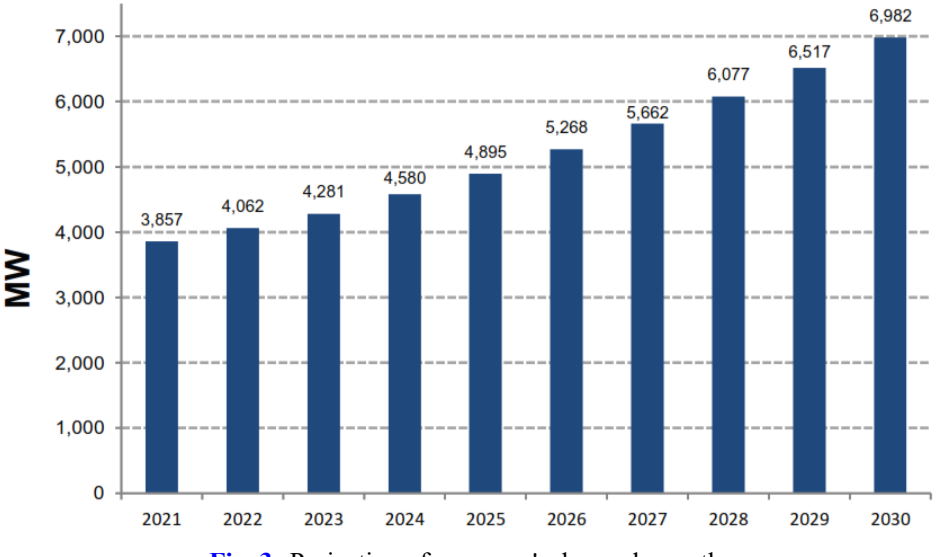

Fig. 3: Projection of paraguay's demand growth.

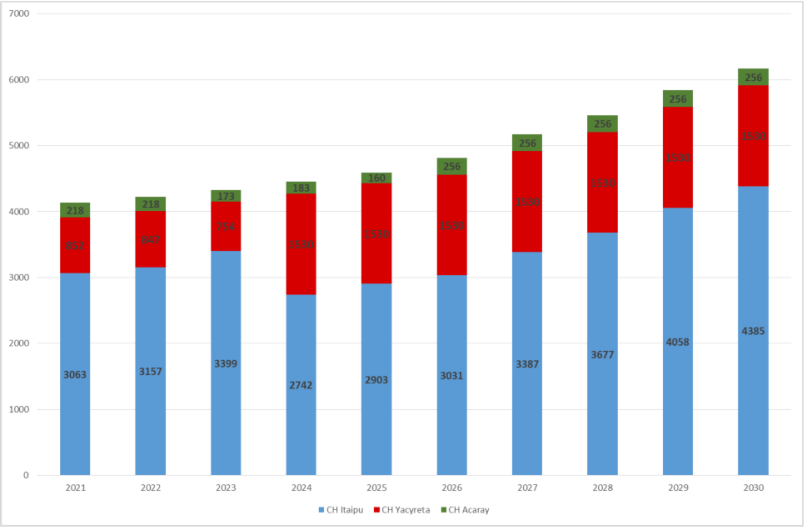

Fig. 4: Hydropower dispatch 2021-2030.

making better use of this situation with the analysis of the question: Can Paraguay freely dispose of the remaining energy that corresponds to it in ITAIPU to be able to market it under different conditions to the current one in other countries' electricity markets? This question leads to an analysis of the Treaty signed by Paraguay and Brazil.

1.1.2 The ITAIPU Bi-national hydropower power plant: an integrating but excluding project

Backgrounds of ITAIPU goes back to a situation of a diplomatic crisis that originated by differences in the interpretation of the border limits, this situation was mitigated the signature of the YGUAZU Act,[5,8] where it was expressed that the territory in conflict is considered in condominium and flooded for its hydropower advantage being divided into equal parts the produced electrical energy and, recognized the right of preference of the energy not used by the other country.

In 1973 the Treaty of ITAIPU was signed, establishing that both countries would have equal rights and obligations.[5] In this Treaty, the term "preferential right" (YGUAZU ACT) is changed to the term "right of acquisition" (TREATY), which creates a barrier of freedom for both countries to be able to commercialize, according to their criteria, the electricity that by right corresponds to them (this being the particular case of Paraguay with its surplus).

Regarding ITAIPU's original project, it was designed with a nominal jump of 118 meters.[5] This variation leads to an increase in the power of the generating units; this power is called ITAIPU's surplus power. At present, ITAIPU has a greater jump due to the postponement of the construction of the CORPUS CRISTI Hydropower Plant (the hydropower project CORPUS CRISTI is a Binational venture between Argentina and Paraguay that would be installed water under ITAIPU and water above YACYRETA as published in COSIPLAN), in which it is clarified that the deprivation of gross jump in ITAIPU could reach 15 meters depending on the superior level established in the CORPUS projects.

ITAIPU has 20 generation units with 700 MW each, with 18 units working constantly (9 units for each country) and the other 2 as reserve units. The operation of the 20 turbines is restricted by the Tripartite Agreement signed between Paraguay, Argentina, and Brazil in 1979.[5]

1.1.3 ITAIPU energy contracting

The agreement established in the Treaty of ITAIPU regarding the provision of electricity service to the purchasing companies (monopsony, ANDE and ELETROBRÁS) is found in Article XIII, where it states that the energy produced will be divided equally between the two countries.

Assuming that Paraguay would not have a way of consuming all of its parts in a long period (considering its domestic market), it was determined through Reversal Note No. 5 in 1973,[5] which ANDE would have the priority of defining its need for power to contract (on its part), and all that power not contracted (surplus of Paraguay's right) ELETROBRÁS would have to contract it. This condition of assured sale was what made possible the payment of the financial obligations of the entity ITAIPU.

1.1.4 Binational approach-compensation for energy assignment

Regarding the issue of compensation for energy cession and even if the association was legally parity between the High Parties, Brazil, in addition to half of the energy to which it is entitled, would also acquire, for a long time, a large part of the energy to which it is entitled to acquire from Paraguay. It was therefore considered that it would be fair to compensate Paraguay.[13]

The concept of compensation for the cession of energy should not be confused with the concept of tariff or price. Paraguay does not sell its energy for the value of the compensation for energy cession, as is currently published in the local press. This value is added to the tariff; it is part of an additional profit or rent (additional to the cost of the service,

which already includes other revenues: profits and compensations for ANDE and ELETROBRAS; and royalties for the partner states).

The compensation mechanism for energy cession could be considered, with certain limitations (because it is not fully applicable), in terms of financial options such as a "Call Option" (it is actually a "de jure" option, but which in fact becomes an obligation since 50% of all the energy produced by ITAIPU corresponds to Paraguay) or an option for Brazil to purchase the energy that would correspond to Paraguay (the partner countries committed themselves to contract all available power (not energy) as established in the Sole Paragraph of Article XIII of the Treaty of ITAIPU). In practical terms, Brazil pays an additional value to CUSE for the energy that it withdraws from ITAIPU and that corresponds to Paraguay and that is not consumed in this country. In this way, ITAIPU acts only as a billing and transfer agent, since it transfers the respective values to the High Contracting Party that transfers the energy, in this case, Paraguay.

The amount established in the Treaty for the compensation defined in Annex C is 300 USD per GWh transferred to the other High Contracting Party,[9] this value is adjusted by the values of FA Adjustment Factor (which represents a form of the effects of inflation and keeps the amounts defined in the Treaty constant) and the FM Multiplier Factor. This value is also adjusted by the values of the FA Adjustment Factor (which represents a form of the effects of inflation and keeps the amounts defined in the Treaty constant) and the FM Multiplier Factor.

It took several years to maintain this condition for Paraguay to obtain, through Reversal Notes in 2005, the modification of raising the FM to 5.1, obtaining an increase of 27.5% concerning the value of the previous year. The 2009 Agreement triples the FM, with this new value the amount of approximately 10 USD per MWh, with which the State of Paraguay would be receiving some USD 360 million annually,[9] this Agreement will be presented in section 2 of this book.

The present work is framed in proposing alternatives for the increase of benefit considering the surplus in electricity of Paraguay, which is traced in the general objective, for which reason the proposals of overcoming the barriers established in the Treaty of ITAIPU, on the availability of commercialization in market conditions, of its remnant of electrical energy, are presented below. Therefore, it proposes an analysis of the regional energy integration processes, considering that they could establish mechanisms for the sale to third countries or another alternative to maximize remunerations of such remnants.

1.2 Regional energy integration opportunity commercialization of ITAIPU's electric energy?

The electrical interconnections in operation in South America are exclusively Bi-national initiatives developed in hydropower undertakings and/or transmission lines.[9,10] With this, it can be said that in the Southern Cone there are already the minimum electrical installations necessary to transport the energy from the Bi-national entities to the electrical markets between the partner countries. Against this background, we analyze how the issue of electricity integration is dealt with in the regional integration initiatives most related to the Southern Cone: MERCOSUR and UNASUR, to understand how it has been dealt with in energy integration, particularly electricity integration, and whether they have sought to resolve regulatory barriers and techniques related to international electricity transactions. To extend the analysis, the electricity exchange regulations in the Andean Nations Community (CAN) and Central America are compared with its Central American Integration System (SICA), to identify the replicable model in the subregion, and thus meet the objective of this analysis.

1.2.1 Electrical interconnection agreements in the CAN

The Andean integration process began with the signing of the Cartagena Agreement on May 26, 1969. Later, in 1996, the name was changed to CAN, made up of Bolivia, Peru, Ecuador, and Colombia. The CAN considers energy integration as one of the axes of economic growth, which is why it has focused on developing it. In this sense, in 2002, the general framework for electrical integration was approved with Decision CAN 536. Table 1 shows a summary of the Decisions and how they established partial solutions for the distribution of rents due to congestion in the countries.[11]

In the early 2000s, Ecuador went through an energy crisis, increasing its market price. In that period, Colombia had a lower marginal cost of operation. With this difference in costs, the flow of energy was predominant from Colombia to Ecuador. This originated with the purchase of energy for USD 183.3 million, which represented a saving of about USD 83 million in fuel purchases from Ecuador.[11]

The main conflict of the CAN was the management of rents for congestion, mitigating this situation with the equitable distribution between Ecuador and Colombia. However, this integration model failed to overcome the dimension of bilateral arrangements, without achieving an effective regional integration character.

For a Transaction (TIE), each generation agent and its respective price are analyzed, estimating a stepped hourly curve of Offer Prices for each Border Node for Export (PONE Curve). Each step of the PONE establishes costs and charges for energy delivery at the border node in USD/kWh. For the activation of a TIE, a nodal price difference threshold equal to 8% is established, which will be adjusted by the Regional Electricity and Gas Commission of Colombia (CREG).[11,12]

1.2.2 Central American integration system SICA

On December 13, 1991, in Honduras, the Tegucigalpa Protocol was signed, which gave rise to the Central American Integration System (SICA). It is made up of the governments

Table 1: Evolution of the decisions of the CAN.

Politics	Description
CAN 536	No price discrimination Free access to international interconnection links No subsidies or taxes will be a applied to the TIE's Congestion rents will pass to the exporting country
CAN 720	Suspends decision CAN 536 for two years There will be no discrimination between the internal agents of each country, except for the supply or electricity The rents will be assigned in equal parts
CAN 757	Extends the suspension of decision CAN 536 Transitional regimes included transactions between Colombia-Ecuador, and Ecuador-Peru
CAN 789	The Andean electrical interconnection system (SINEA) was created. It was recommended to suspend decision CAN 536 and continue analyzing the harmonization of regulations

of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama, which decided to create the Regional Electricity Market (MER),[1] in order to promote regional electricity integration. For this, the concept of a seventh virtual market was defined, parallel to the national ones (independent regulations). Physical exchanges in the MER are carried out through a trunk transmission line (capacity of 300 MW between borders), called the Electrical Interconnection System for Central America (SIEPAC).[13]

For the dynamism of the Regional Electricity Market, the following were created: i) the Regional Operator Entity (EOR), in charge of technical and commercial operation of the market; ii) the Regional Electricity Interconnection Commission (CRIE), which acts as a regional regulator and iii) the Owner Company of the Network (EPR) which is the public limited company that owns the trunk line. For transactions in the MER, a nodal price system is used, which represents the short-term marginal prices of energy in each node of the Regional Transmission Network (RTR). With an economic dispatch objective function and the allocation of transmission services, nodal prices are obtained, solving a price optimization problem.[7] The EOR performs the pre-dispatch of the MER with a mathematical model that takes into account nodal injection and withdrawal opportunity offers, maximizing the social benefit. This model achieves true market integration, without discrimination between agents and maximizes social benefit.

1.2.3 Southern common market (MERCOSUR)

MERCOSUR's limited progress on electricity integration was expressed in Decision CMC N°10/98 on electricity exchanges and integration. This document expresses general criteria for the exchange of electrical energy, the complementarily of energy resources, and the placement of energy surpluses.[9] However, this intention was never internalized as normativein any of the countries.[14] Nor was the restriction on the sale of energy from binational entities to third countries resolved, so it does not represent a solution to the issue raised in this paper.

1.2.4 Union of south American Nations (UNASUR)

One of its objectives is regional energy integration and for this purpose, it has the South American Energy Council (CES). Although several meetings of this ESC have taken place, progress has been very limited, achieving only one structure for a South American Treaty, in which the need to respect previous bilateral agreements between nations Botero *et al*.[14] and Oliveros *et al*.[15] is highlighted. Therefore, it is concluded that UNASUR has not managed to advance in the establishment of a regional energy market and therefore does not constitute a solution to the issue raised in this paper.

1.2.5 Summary of integration models analyzed

In Table 2, a comparison of the degree of progress and applicability of each model analyzed in this work.[14-16] It can be seen that the model proposed by the CAN only make progress in bilateral agreements; On the other hand, SICA achieves integration with more effective regulations for its implementation. Although none of the intentions of Regional Integration proposes a solution to overcome the barriers to the freedom of commercialization of electrical energy established in the ITAIPU Treaties, there is the possibility that the Lula-Lugo Agreement proposes, which is detailed below.

1.2.6 Lula-Lugo agreement between Brazil and Paraguay

On July 25, 2009, the Presidents of Brazil and Paraguay met to sign an agreement of thirty-one points of bilateral interest. This work has a main interest in the following points (Lula - Lugo Agreement, 2009):[17]

- Point 5: on the increase of the Multiplication Factor of 15.3
- Point 6: They recognize the convenience of ANDE gradually being able, as soon as possible, to commercialize in the Brazilian market energy corresponding to Paraguay's acquisition rights.

It can be said that the Lula-Lugo Agreement raises the possibility of commercializing the surplus or remnants of Paraguayan electricity in the Brazilian market under market conditions, being able to negotiate to increase its profits due

Table 2: A comparison of the degree of progress and applicability of each model.

Perspective		CAN	SICA	MERCOSUR	UNASUR
Method	Bilateral	X	X	It did not prosper; it remained a manifestation of intent	Without much progress
	Multilateral		X		
Enforcement	Short term	X	X		
	Long term		X		

to its electricity surplus; therefore, a study of the possible sales mechanisms in the Brazilian market model is carried out below, considering its structure and regulation.

1.2.7 Brazilian electricity market: a first step, alternatives to paraguayan energy commercialization

The Brazilian electric sector is based on Federal Law 10848/2004, in this legal instrument, among other issues, it was determined the creation of two environments of commercialization of electric energy: The Regulated Contracting Environment (ACR); and the Free Contracting Environment (ACL). In parallel (or complementary) to these contract environments, the Short-Term Market (MCP) is developed, with the Chamber of Commercialization of Electric Energy (CCEE) in charge of making adjustments for contract balances based on the Price settlement of differences (PLD acronyms in Portuguese).

The Regulated Environment is developed to contract the electricity necessary to guarantee compliance with the Chamber of Commercialization of Electric Energy (CCEE) in charge of making adjustments for contract balances based on the Price settlement of differences (PLD acronyms in Portuguese).

The Regulated Environment is developed to contract the electricity necessary to guarantee compliance with the electricity demand of captive customers, who receive the energy supply from the distributors. The process of electricity contract by distributors and generation plants is developed through auctions; a mechanism that promotes competition among generation agents, meeting the requirements of supply security and tariff "modicity".[18]

In the Free Contracting Environment (ACL), contrary to ACR, generators, free consumers, self-producers, and electric energy marketers establish among themselves bilateral contracts, settling the purchase and sale clauses, with prices and quantities freely negotiated, according to the rules and marketing procedures specified by the National Electric Energy Agency (ANEEL).[18]

The Short-Term Market is operated and settled with the PLD Price settlement of differences, which is used to value the energy transactions resulting from the balances between the contracted quantities and those actually generated and consumed. The PLD is obtained from the application of the operation and pre-dispatch optimization models for the National Interlinked System of Brazil (SIN) used by the National Electric Service Agency (ONS).[19] The optimization models used are: NEWAVE and DECOMP, these models propose optimal solutions for the use of hydropower dams, arbitrating between the present benefit for the use of water and the expected future benefit for storing water, reducing the expected operating costs for the use of fuels and the costs for failure and interruption of supply.[18]

Currently, Brazil can import electricity from Uruguay and Argentina through Regulation 530/21, in which it is stated that the destination of the imported energy will be the short-term market, consequently at PLD prices.[20] This work is based on this premise for the profitability calculations of Paraguayan energy sales in the Brazilian electricity market. The following chapter will detail the methodologies and tools applied to achieve the objectives proposed in this work.

2. Methodology

Based on the review of the literature and consequently with the objectives established in this work, an analysis procedure was carried out as shown in Fig. 5, whose steps will be described below.

- Concerning specific objective 1, a bibliographic review was carried out of the progress made within the framework of regional energy integration more closely linked to the reality of Paraguay. The purpose was to identify a legal instrument that would allow or at least indicate the possibility of commercializing Paraguayan energy from Bi-national entities under conditions different from those outlined in the Treaty of ITAIPU.

- Concerning objective 2, with which it is proposed to identify the modalities of the sale in the Brazilian market, the following possibilities were found: In the Regulated Contracting Environment ACR, Free Contracting Environment ACL, and the Short-Term Market.

This section of the work focuses on the presentation of methodologies and tools to be used to achieve the main objective of the research, based on the Theoretical Framework (see section 3), which reinforces the hypothesis that Paraguay has an energy surplus, and this situation would be maintained for an extended period, which should be used. In this sense, this work intends to contribute to the reflection and academic analysis on the viability and benefits that would be obtained in the case of commercializing energy under conditions different from the current ones, using as a base the proposals developed in Appendix A.

Based on the possibility of commercialization established with the Lula-Lugo Agreement and Portaria 530/21 of the

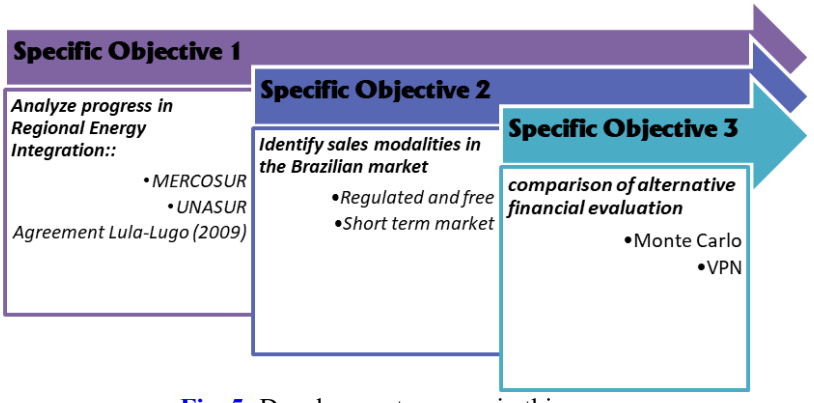

Fig. 5: Development process in this paper.

MME,[20] and through a review of the literature, it was possible to identify the existence of sales modalities in the Brazilian electricity market (presented in the section 2.3), thus achieving a specific objective 2 . Thus, it was identified that an initial modality of sale of electric energy in Brazil would be that of the short-term market with PLD prices, so this research focuses on sales alternatives in this modality, considering the following case studies:

i) The sale of Paraguayan energy associated with the surplus power in ITAIPU, considering that it is uninsured energy, but with a significant occurrence in the historical generation; and ii) The sale of Paraguayan energy associated with the surplus power in ITAIPU, considering that it is uninsured energy, but with a significant occurrence in the historical generation; and iii) The sale of Paraguayan energy associated to the surplus power in ITAIPU, considering that it is uninsured energy, but with a significant occurrence in the historical generation; and iv) The sale of Paraguayan energy associated with the surplus power in ITAIPU, considering that it is uninsured energy, but with a significant occurrence in the historical generation.

ii) The sale of remaining or surplus power associated with ANDE's contracted power if current contracting levels are increased. This remaining energy could be used to market in Brazil.

iii) These two case studies will be evaluated and compared according to financial profitability indicators. Both cases studies have variables whose future projections present uncertainties, which is why mathematical methods will be used to treat these variables such as: projection of surplus power levels of ITAIPU until 2017; and the demand of Paraguay's internal electricity market.

The methods to be used for the treatment of these variables are the following:

Monte Carlo method: initially ANDE's projection of electricity demand (see Fig. 3) does not precisely identify the period when Paraguay is using all of its installed capacity in generation, so it is inevitable to ask the question: until when would Paraguay have this surplus of electricity? This question calls for a demand projection, and this is where the Monte Carlo method is applied. Unlike other traditional methods of linear projection, this method can include uncertainties in the evolution of electricity demand, treating it as a stochastic process (Blanco, 2015). This method will also be used for the projection of ITAIPU's surplus power for the year 2017.

- Concerning specific objective3: Financial Analysis: this analysis arises from the need to compare cases of energy sales established. It would be based on the use of economic indicators widely used in the literature regarding investment projects, such as the Net Present Value (NPV),[21] for which it would be necessary to analyze: energy available for sale and market prices. With this, it will be possible to estimate income and expenditure by presenting the results in a cash flow format.

3. Results and discussion

In this section of the book, the processes developed for the analysis of the case studies will be presented to achieve the objectives formulated in the following way:

To concerning specific objective 1: from the analysis of regional integration processes, it can be inferred that the current mechanisms: MERCOSUR and UNASUR do not contemplate a means of overcoming the barriers established in the Treaties of ITAIPU and YACYRETA to the restrictions on the commercialization of energy to the countries. However, through the Lula-Lugo Agreement, the possibility is raised that ANDE will gradually commercialize the energy that corresponds to it in ITAIPU due to its acquisition rights in the Brazilian electricity market. This means that such commercialization would take place under different conditions to those outlined in the assignment modality.

To objective 2, with which it is proposed to identify the modalities of the sale in the Brazilian market, the following is detailed: In the Regulated Contracting Environment: that Paraguayan energy could enter the Brazilian market ACR in its category of old energy or A-1 auction, considering that ITAIPU is a plant with a proven generation trajectory and guaranteed production (the old energy modality stipulates that they can participate in the same plants financially already amortized. In the case of ITAIPU, the total payment of the debt contracted by ITAIPU for its construction is foreseen for the year 2023). For the sale in this modality it is necessary to commit a power block for 8 years or more, being the reference

amount the average price of 36.58 USD/MWh, 55 USD/MWh, and 54 USD/MWh,[22] being the sale price of energy in this modality higher than the Cost of Energy in ITAIPU of 43.68 USD/MWh,[4] this possibility is not contemplated as possible, since ANDE should initially carry out its contracting projections again so as not to compromise its internal market, this possibility being feasible in the medium term, but without reaching the critical period where Paraguay uses all its installed capacity in a generation. Therefore, this possibility will not be analyzed further in this study.

In the Free Contracting Environment, if it is possible to reach an agreement with a large client, fair remuneration should be defined, evaluating the market conditions. This modality could be viable in the medium term. For this, it would be advisable to have access to information on the values of contracts currently in force, information that is not readily available at this time. In the Short-Term Market, this modality represents an opportunity for the sale of Paraguay's remaining electric energy, which will be analyzed in greater depth below.

3.1 Analysis of proposals to increase the use of surplus energy in Paraguay

Paraguay, as an electricity producer, ranks first in the list of countries with "least polluting" electricity systems (in the sense that it uses renewable sources) in the world.[22] This achievement is possible thanks to the country's large hydropower production capacity with Bi-national hydropower plants and ANDE's ACARAY plant.

According to what has already been mentioned, the ITAIPU Bi-national Hydropower Plant is the one with the highest values of installed capacity, available power for contracting and generation. In it, some values could exceed the results calculated in the project. In fact, under favorable hydrological and leap conditions, it has allowed the recording of generation values well above the power allowed by the Tripartite Agreement signed in 1979.[9]According to the data from Project 14-INV-283 and ANDE once processed, it was possible to elaborate a historical power curve (see Fig. 6 and Table 3) and a historical surplus power of the ITAIPU Hydropower Plant (see Fig. 7 and Table 4). ITAIPU 2014-2016 Surplus Power Data).[9,22,23] This surplus power is associated with energy being an unsafe energy supply, which could not be sold directly in the Brazilian electricity market in their ACR or ACL.

This paper focuses initially on the study of the surplus power of ITAIPU (see Appendix) and its associated energy from 2014 to 2016, to estimate the income from its sale in the short-term market in Brazil. Subsequently, the profitability analysis of the increase in ITAIPU's contracting of greater power by ANDE is presented, with which ANDE would have an associated excess or remaining energy that corresponds to it. With this energy, it would be possible to enter the short-term market to capture extraordinary rents at PLD prices.

Before the analysis of the cases presented, Appendix answers the question of how long would Paraguay have its electricity surplus? Projecting demand using the Monte Carlo method, estimating that in 2031 supply would be matched with electricity demand. Under the particular and favorable situation in which Paraguay is in a surplus even for a long period, it can be said that the government of Paraguay, through ANDE or a trading company should seek alternatives to maximize revenue from its remaining electricity, since currently only receives a fixed value of compensation for the cession of energy.[23] Therefore, in Appendix, the question of processes for the creation of an electricity trading company in the Brazilian electricity market is broken down; identifying that at least 6 months of bureaucracy would be required.

3.2 Would Paraguayan energy sales associate with the surplus power in ITAIPU be profitable?

Regarding the surplus power available at ITAIPU, as explained in section 2.1.3, there is the energy associated with that power, the cost of which is approximately USD 4.2 per MWh (2003 value) adjusted annually according to the adjustment factor. This cost represents the marginal cost of production of this energy in dollars per megawatt-hour only for ITAIPU.[4,9]

The distribution and ownership of the surplus energy of the hydropower plant have been widely discussed within the Committee for Administration and Operation of Purchase and Sale Contracts of the Electricity Services of ITAIPU (CADOP) since there were two different aspects: some defended that the ownership of the energy was proportional to the relation of power contracts of the binational plant; others defended the

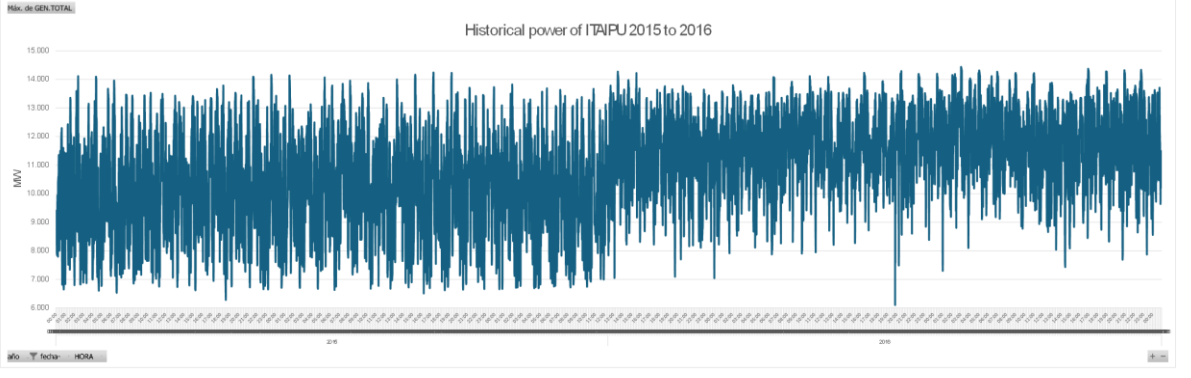

Fig. 6: Historical power of ITAIPU 2015 to 2016.

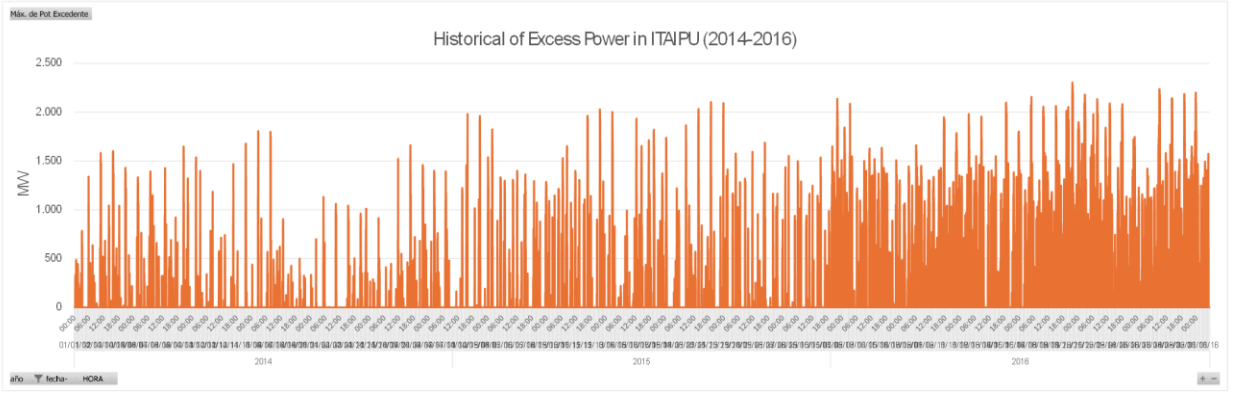

Fig. 7: Historical of excess power in ITAIPU (2014-2016).

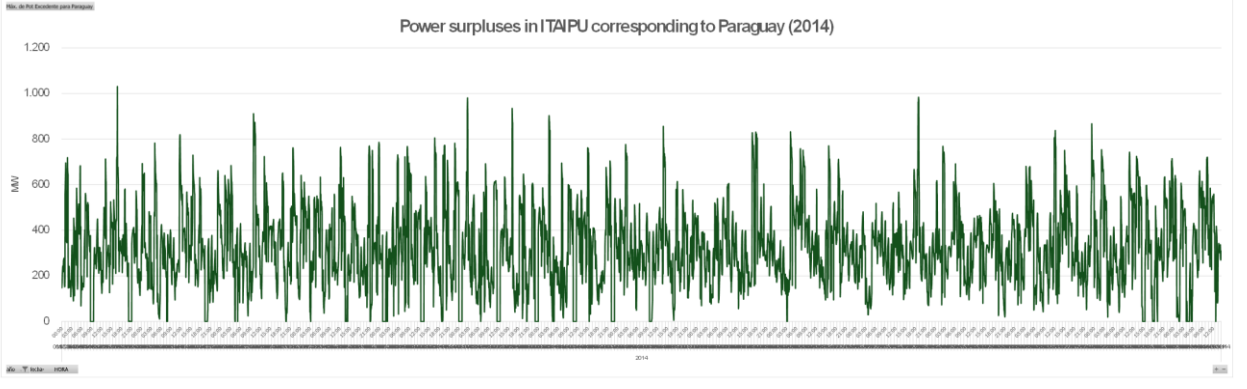

Fig. 8: Power surpluses in ITAIPU corresponding to Paraguay.

Table 3: ITAIPU 2015-2016 power data.

Power data ITAIPU (2015-2016)	
Amount of data	17543
Maximum values (MW)	14438
Average values (MW)	10962
Standard derivation	5.6%

Table 4: ITAIPU 2014-2016 surplus power data.

Power surplus data ITAIPU (2014-2016)	
Amount of data	26280
Maximum values (MW)	2154
Average values (MW)	758

distribution in equal parts among the partner countries. The Committee for Administration and Operation of Purchase and Sale Contracts of the Electricity Services of ITAIPU (CADOP) since there were two different aspects: some defended that the ownership of the energy was proportional to the relation of power contracts of the binational plant; others defended the distribution in equal parts among the partner countries. The Administration Council using Resolution 020/2002 established that the surpluses will be of the equal property of the High Contracting Parties, considering that if one of them does not consume the parcel of the surplus energy to which the other has the right to use it paying the compensation for the cession of energy specified in Annex C of the Treaty.

Starting from the postulate that Paraguay, apart from its guaranteed electricity surplus, additionally has a surplus which is the surplus of ITAIPU, which has a very low cost compared to the standard tariff (non-guaranteed energy cost of 4.2 USD/MWh compared to the guaranteed of 43.68 USD/MWh). This energy could be used to maximize revenues if this energy can be marketed in the Brazilian market. The historical surplus power of ITAIPU recovered from Project 14-INV-283 and ANDE,[9,23] which is counted from 2014 to 2016, once this information was processed, their curves were elaborated as can be seen in Fig. 8. It can be observed that the maximum surplus power for Paraguay registered between 2014 and 2016 was 1,074 MW, being that for the remaining period to finish 2017 were projected with the Monte Carlo method.

Considering the variation in the short-term market with the fluctuation of the PLD throughout a year, the first approximation of income could be obtained considering the lower and upper limits established by the ANEEL annually, with these values one could estimate the income from sale in this modality of the Paraguayan energy associated with the surplus power of ITAIPU see Table 5.

Looking at the historical analysis mostly fulfilling specific objective 3, the published values of the PLD can be considered as the amounts that would be paid for Paraguayan energy in the short-term market.[22]

Table 5: PLD limits from 2014 to 2017 (CCEE, 2017).

Historic PLD (USD/MWh)	
Price 2014	4.84 to 255.07
Price 2015	9.38 to 120.42
Price 2016	9.38 to 130.90
Price 2017	10.44 to 165.48

To estimate the potential income that the trading company would have from the sale of Paraguayan energy in the Brazilian market, the following procedure is followed in Eq. (1):

$$Income = Energy_{annual} * PLD_{historical} \quad (1)$$

where $Energy_{annual}$ is the energy associated with the surplus power of ITAIPU that corresponds to Paraguay, $PLD_{historical}$ is the historical value of the PLD.

Calculation of the profitability of the sale of surplus electric energy corresponding to Paraguay must take into account the possible income, but even more must consider the expenditures as costs of this energy and other expenses, with which it could be considered if it is economically feasible to create a commercialization company in Brazil or to continue in the current conditions of compensation for the cession of surplus energy from Paraguay. For this calculation, the following procedure was used:

Table 6: Maximum and minimum income per sale of energy at PLD value.

Year	PLD (USD/MWh)	Surplus energy (MWh/year)	Financial income
2014	4.84 to 255.07	2,842,448	13,757,449 to 725,026,234
2015	9.38 to 120.42	3,328,608	31,222,338 to 40,083,917
2016	9.38 to 130.90	3,787,373	35,525,558 to 495,767,120
2017	10.44 to 165.48	4,284,787	44,734,332 to 709,064,869

Income: Income is considered to be the value received from the sale of surplus electricity from Paraguay at PLD values.

Expenditure: the potential expenses incurred were estimated:

-The amount necessary for the qualification of a trading company in the electricity market to be credited to the CCEE,

- The cost of the electric energy associated with the surplus power to be paid to ITAIPU,

- Taxes to the State of Brazil.[24]

Income tax (IR) of 15% on income,

Contribution taxes to the Social Integration Program and Formation of Public Service Patrimony (PIS) of 0.65% on income,

Social Security Financing Contribution Rate (COFING) of 3% of estimated net income,

Foreign exchange tax, established as the Financial Operations Tax (IOF), of a value of 10% to the profit generated.

Compensation to the Paraguayan State, which is considered as the payment to the Paraguayan State for the ownership of this energy; this amount is established for fiscal year purposes, as the value it receives for the compensation for the assignment of Energy to Brazil of approximately 9.34 USD per MWh (It is clarified that the compensation value for energy cession of 9.34 USD/MWh is a reference amount, it should be updated with the Adjustment Factor, this amount is used for reasons of not having the updated value, only projections are available), established based on the Lula-Lugo Agreement (Lula - Lugo Agreement, 2009).[17]

The results shown in Table 6 can be obtained in the manner provided by the equation of income from the sale of energy at the PLD value established by ANEEL,[22] and between the minimum and maximum for each year within the period studied (2014 to 2016).

From the table above it can be estimated that marketing could be profitable considering the established extreme values of PLD. Considering the PLD values by load levels, which vary each week, a more precise calculation can be made of the potential income from the sale of surplus energy, as shown in Table 7. These values estimate in a more detailed way the untapped income opportunity, but this potential income must be discounted by some expenses as detailed below.

The cost of this energy paid to ITAIPU must be deducted from this income. This cost is very low at about 4.2 USD per MWh (This value is only taken as a reference and must have the same adjustment by means of the FA as mentioned above)

Table 7: Income considering weekly minimum PLD.

Year	Minimum financial income
2014	586,222,305
2015	332,177,748
2016	98,164,350
2017	324,564,889

compared to the normal power rate of 22.6 USD/kWmes equivalent in the energy cost of 43.68 USD per MWh as published in (ITAIPU, 2016). This cost corresponds to the payment of royalties, compensation of administrative and supervisory charges (Table 8).[13]

Table 8: Cost in USD of commercialized surplus energy.

Year	Cost of energy per year
2014	11,938,282
2015	13,980,152
2016	15,906,966
2017	17,996,570

In addition to the estimates of expenditure, some costs were established that could be considered as fixed costs:

-The amount established by ANEEL as liquid equity of one million Reales equivalent to approximately 310,000 USD, considered only in the zero years of cash flow.[20,25]

- The minimum monthly operational limit published by the CCEE of 100 thousand Reales equivalent to 31,000 USD per month.[9]

- Rental of office for the premises of the marketing company of about 2,000 USD per month.

- For the payment to the person they were estimated in reference values of the order of:

- Manager with a salary of 6,000 USD per month
- Systems Analyst with a monthly salary of 3,500 USD
- Lawyer with a monthly salary of 3,500 USD
- Secretary with a monthly salary of 1,500 USD
- Miscellaneous expenses of USD 3,300 per month
- Payment of emolument or economic remuneration to the CCEE of 22,039 REALES -Brazilian Currency- to Accession (enabling) the same as a single payment, which was rounded to about 10,000 USD considering miscellaneous expenses.[20,25,26]

Totaling a monthly outflow amount of 50,800 USD is considered in the analyzed cash flow. With the previously estimated values, a cash flow can be constructed where the profitability of the proposal for the commercialization of Paraguayan surpluses in the Brazilian market could be valued at present. To analyze the possibilities, the price of the PLD is considered three cases where (i) the maximum PLD for each year (Table 9), (ii) the minimum PLD for each year, (iii) and the historical PLD published by CCEE.[22]

This cash flow valued at 2017 with a discount rate of 8% used in this work (being this discount rate the one used in the projects of the National Electricity Administration ANDE and considering that ANEEL establishes a regulated rate of 7.5%, it could be said that this case study for the 2014-2017 period would have a Net Present Value of 1,733,658,577 USD. However, considering the minimum PLD as remuneration, it is found that commercialization is not profitable, see Table 8. Considering that in this situation the State of Paraguay could exonerate the Distributer (it is considered the compensation value that the distributor must pay to the State, being that for this analysis it is not specified if it would be a company with a concession or some other type of business-State treatment) from contributing to compensation of 9.34 USD/MWh, the

Table 9: Cash Flow considering the historical MAXIMUM PLD.

Description		Year zero	2014	2015	2016	2017
Income per sale (PLD max)			725,023,234	400,830,917	495,767,120	709,064,869
Cost of energy IB			-11,938,282	-13,980,152	-15,906,966	-17,966,570
	Income tax		-106,962,743	-58,027,615	-71,979,023	-103,660,245
Other expenses	Contribution PIS+COFING		-26,463,348	-14,630,328	-18,095,500	-25,880,868
	Staff and other		-609,600	-609,600	-609,600	-609,600
	Compensation Py		-26,548,465	-31.089,194	-35,374,063	-40,020,944
	CCEE and others	-10,000	-372,000	-372,000	-372,000	-372,000
	Patrimony (ANEEL)	-310,000				
Subtotal		-320,000	522,128,796	282,122,028	353,429,968	520,524,642
Tax IOF		-32,000	55,212,880	28,212,203	35,342,997	52,052,464
Utility		-352,000	607,341,676	310,334,231	388,722,965	572,577,106

flow becomes positive, see Table 10, with which it is possible to obtain an NPV (8% discount rate) of some 40,125,363 USD brought to 2017.

Once the financial feasibility has been visualized in the extreme cases of PLD, a more detailed analysis can be carried out taking into account the published values of PLD. With this, the profitability of this situation could be estimated as detailed in Table 11, which presents an NPV value (rate of 8%) of approximately 951,109,404 USD evaluated as of 2017.With the results of the previous analysis, it can be argued that it is feasible and profitable to sell Paraguayan energy associated with surplus power in the short-term market in Brazil, for which reason the analysis of the second case study follows (Table 12).

3.3 Would it be profitable to sell the remaining energy through the increase of power contracting by ANDE in ITAIPU?

The strategy of power contracting by ANDE in ITAIPU has always been to contract below a projected demand to optimize payments as commented in an interview by Mr. Fernández. This is based on the fact that ITAIPU makes available its guaranteed energy and additionally the energy associated with the surplus power with which ANDE covers 79% of Paraguay's total demand.[17] This agreement strategy is optimal from the point of view of reducing costs in a generation, which means an advantage for ANDE.

This section analyzes the possible profitability of increasing this level of contracted power based on the

Table 10: Cash Flow considering historical MINIMUM PLD.

Description		Year zero	2014	2015	2016	2017
Income per sale (PLD max)			13,757,449	31,222,338	35,525,558	44,734,332
Cost of energy IB			-11,938,282	-13,980,152	-15,906,966	-17.996,570
Other expenses	Income tax		-272,875	-2,586,328	-2,942,789	-4,010,664
	Contribution PIS+COFING		-502,147	-1,139,615	-1,296,683	-1,623,803
	Staff and other		-609,600	-609,600	-609,600	-609,600
	Compensation Py		-26,548,465	-31,089,194	-35,374,063	-40,020,944
	CCEE and others	-10,000	-372,000	-372,000	-372,000	-372,000
	Patrimony (ANEEL)	-310,000				
Subtotal		-320,000	-26,485,920	-18,554,551	-20,976,543	-19,908,249
Tax IOF		-32,000	-2,648,592	-1,855,455	-2,097,654	-1,990,825
Utility		-352,000	-29,134,512	-20,410,006	-23,074,197	-21,899,074

Table 11: Cash Flow considering the historical MINIMUM PLD, without compensation to the Paraguayan State.

Description		Year zero	2014	2015	2016	2017
Income per sale (PLD max)			13,757,449	31,222,338	35,525,558	44,734,332
Cost of energy IB			-11,938,282	-13,980,152	-15,906,966	-17,996,570
Other expenses	Income tax		-272,875	-2,586,328	-2,942,789	-4,010,664
	Contribution PIS+COFING		-502,147	-1,139,615	-1,296,683	-1,623,803
	Staff and other		-609,600	-609,600	-609,600	-609,600
	Compensation Py					
	CCEE and others	-10,000	-372,000	-372,000	-372,000	-372,000
	Patrimony (ANEEL)	-310,000				
Subtotal		-320,000	62,545	12,534,643	14,397,520	20,112,695
Tax IOF		-32,000	6,254	1,253,464	1,439,752	2,011,269
Utility		-352,000	68,799	13,788,107	15,837,272	22,123,964

Table 12: Cash Flow considering DWP according to CCEE.

Description		Year zero	2014	2015	2016	2017
Income per sale (PLD max)			586,222,305	332,177,748	98,164,350	324,564,889
Cost of energy IB			-11,938,282	-13,980,152	-15,906,966	-17,996,570
Other expenses	Income tax		-86,142,603	-47,729,639	-12,338,608	-45,985,248
	Contribution PIS+COFING		-21,397,114	-12,124,488	-3,582,999	-11,846,618
	Staff and other		-609,600	-609,600	-609,600	-609,600
	Compensation Py		-26,548,465	-31,089,194	-35,374,063	-40,020,944
	CCEE and others	-10,000	-372,000	-372,000	-372,000	-372,000
	Patrimony (ANEEL)	-310,000				
Subtotal		-320,000	439,241,241	226,272,675	29,980,114	207,733,909
Tax IOF		-32,000	-43,921,424	-22,627,267	2,998,011	-20,773,391
Utility		-352,000	395,292,816	203,645,407	26,982,103	186,960,518

maximum power recorded by ANDE in ITAIPU, thus it can be considered that ANDE would have a surplus or remnant of energy, which could be sold in the short-term market in Brazil.

3.3.1 How much energy could be obtained by increasing ITAIPU's power agreement?

According to what is established in the Treaty of ITAIPU the form of sale of the electricity service is contracting blocks of Power, these blocks must add the totality of the guaranteed production of the power. Analyzing the annual reports of ITAIPU,[36] it is possible to identify the power contracted by ANDE from 2014 to 2016, resulting in Fig. 9.

Making a comparison of the power withdrawn with that contracted by ANDE (see Fig. 10) it can be seen that it contracts levels lower than its needs since the company counts that, in case of deficit and by internal agreement in CADOP, it will be able to complete its need according to the surpluses, to optimize its payment to ITAIPU.

Performing a Histogram of power withdrawn by ANDE and considering the monthly contracts you can check the hypothesis of contract below your needs (see Figs. 11-13, where the red bars are the powers withdrawn above your contract and green the surplus, within the provisions of the contract).

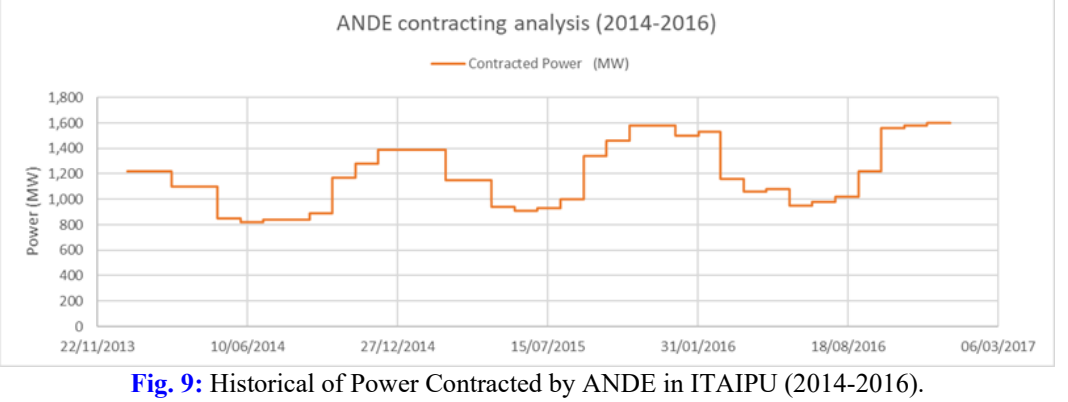

Fig. 9: Historical of Power Contracted by ANDE in ITAIPU (2014-2016).

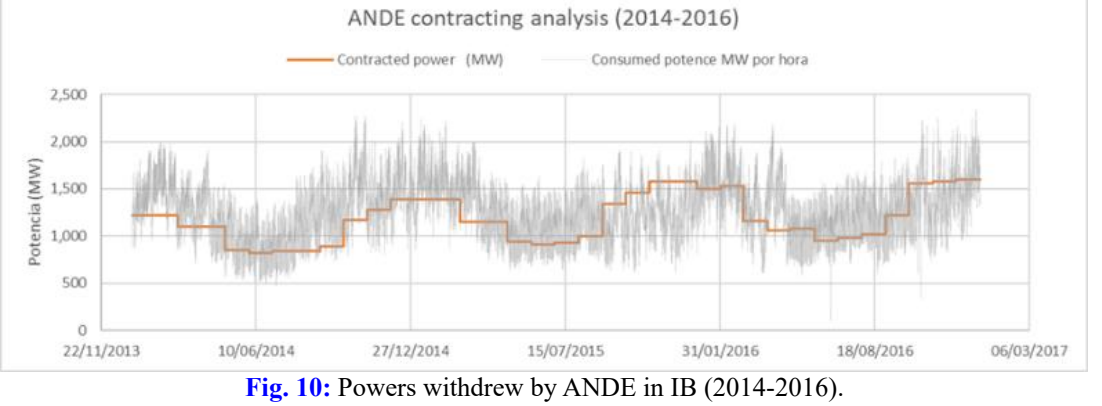

Fig. 10: Powers withdrew by ANDE in IB (2014-2016).

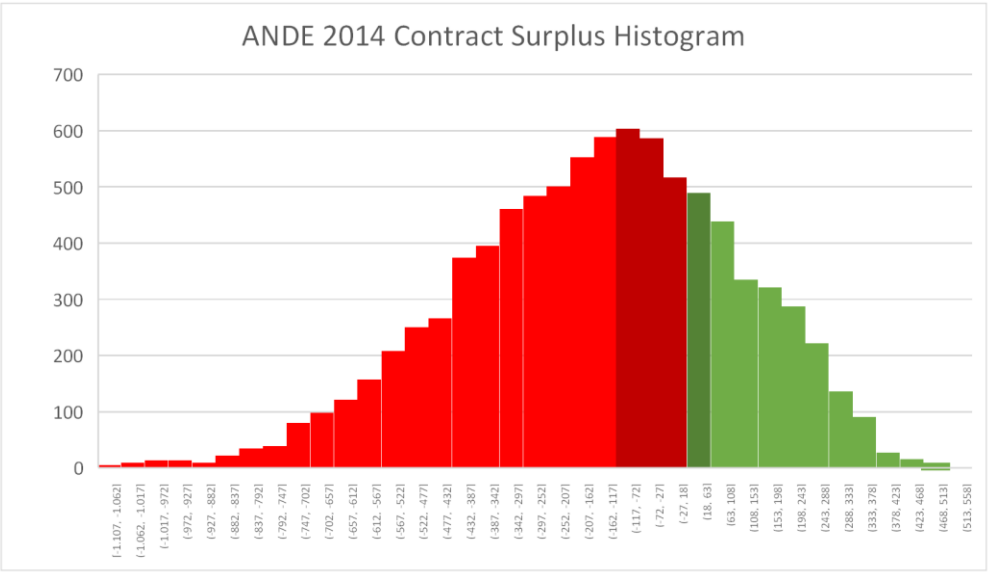

Fig. 11: Power Histogram withdrawn by ANDE 2014.

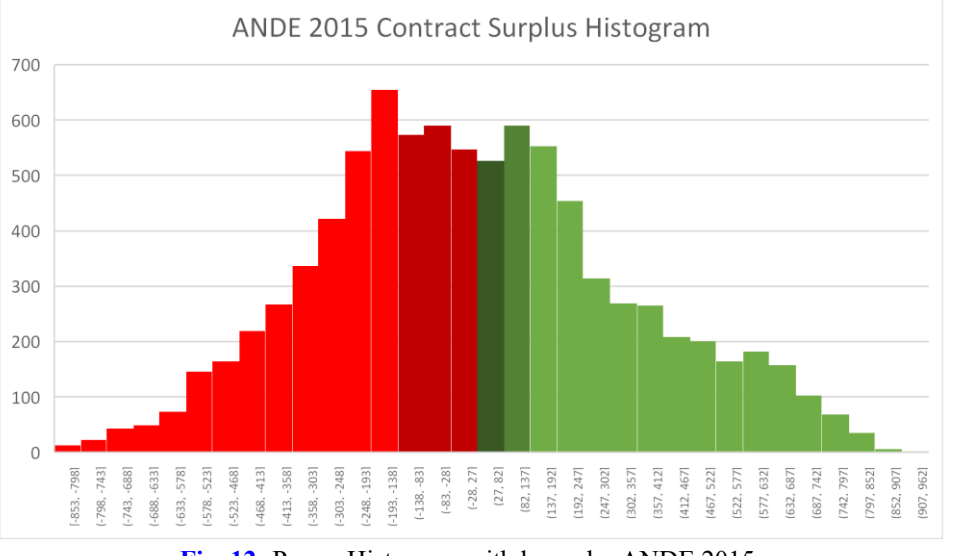

Fig. 12: Power Histogram withdrawn by ANDE 2015.

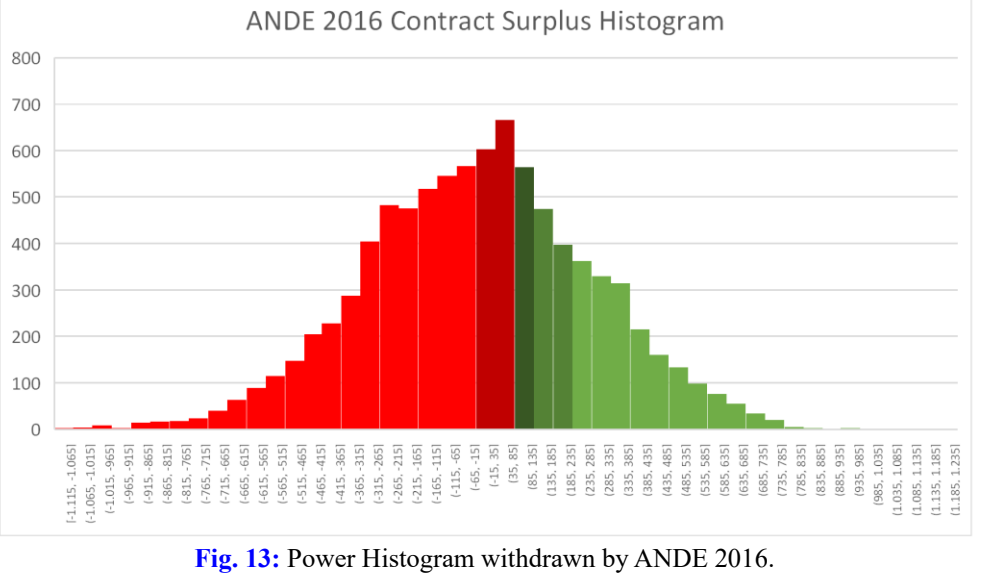

Fig. 13: Power Histogram withdrawn by ANDE 2016.

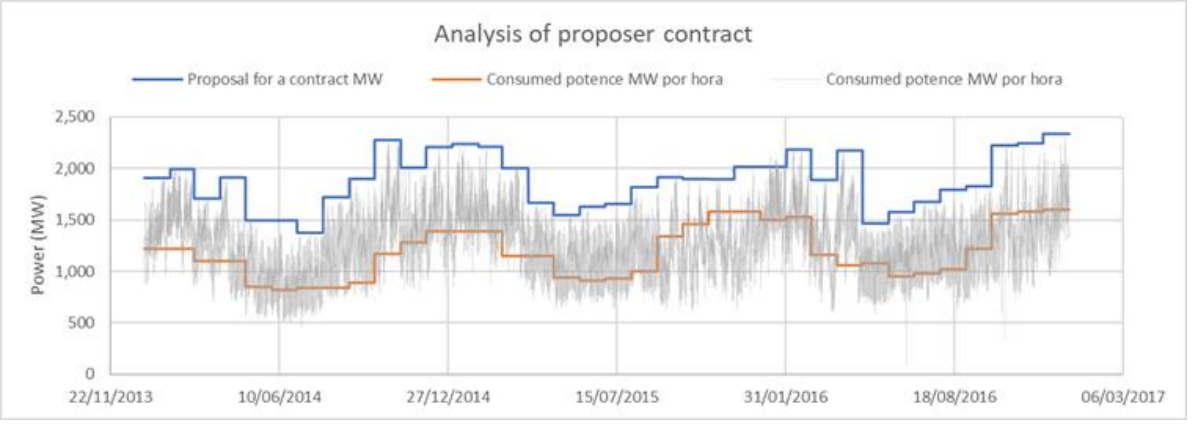

Fig. 14: ANDE contract proposal (2014-2016).

Based on the data presented in the graphs, the profitability of ANDE's contracting of greater power than it usually does is analyzed, with the purpose of having a surplus or remnant that could be commercialized in the Brazilian short-term market, where the payment for such energy would be the Price settlement of differences or Difference Liquidation Price (DPL- PLD), in the same manner as in the previous year.

In this section, it is proposed to carry out an exercise to estimate the profitability of the proposed increase in power contracts. Fig. 14 shows the case in which ANDE hires from ITAIPU its maximum power withdrawn monthly, effectively and according to historical records in the study period from 2014 to 2016, with which a margin could be established where there would be a remnant of power in most of the time in order to trade it in market conditions at PLD values.

Taking into account the considerations presented earlier in this work and favorable conditions of water flows among others, the ANDE could count on a remainder of approximately 5 TWh/year as shown in Table 13.

Table 13: Surplus or remaining energy in the case of maximum demand contracting.

Surplus energy or remaining by procurement proposal (MWh)	
Year 2014	5,409,982
Year 2015	5,769,810
Year 2016	5,897,831

Table 14: Income from the sale of remnant for proposed contracts.

Income for sale of the remnant proposer to PLD-CCEE (USD)	
Year 2014	1,132,567,516
Year 2015	1,618,299,193
Year 2016	630,520,618

Estimating the income from the sale of surplus or remaining energy in the short-term market at PLD values with the weekly values published in the CCEE is presented in Table 14.[22] With the expenditures considered in the previous section, a cash flow can be elaborated (see Table 15) in which the NPV methodology was applied as it was developed in previous years.

Assuming the values analyzed by sale in the periods from 2014 to 2016 and the payment of all expenses considered, this would result in a Net Present Value evaluated to 2017 of approximately 2,252,406,820 USD. Therefore, it can be considered that it would be profitable for ANDE to commercialize the remainder due to an increase in maximum demand contracting. These exercises were elaborated based on historical data of prices of PLD, power and energy, the reason why to estimate the profitability to the average or long term of the commercialization of energy in the Brazilian electrical market, it should be analyzed in the future with the purpose of proposing the best strategies of the sale in this market. This would lead to an examination of the tools and methodology for the projection of the electricity market in Brazil. There are some case studies with the NEWAVE optimization model, being this the model used by the CCEE for the projections of the long-term behavior of the electric power generation sector. In addition to the analysis of the profitability of the commercialization of energy established in specific objectives 1, 2, and 3, the present work aims to estimate the potential impact of the variation of ANDE power contracting in the Brazilian electricity market

4. Conclusion

In the review of the literature, it was identified that there is no clear answer to the issue of electricity integration, so that, in the current conditions of the advancement of the regional legal framework, in the current processes of Regional Integration: both MERCOSUR and UNASUR, have not yet presented a clear and effective solution concerning the functioning of a regional electricity market with the participation of Bi-national hydropower plants. The study has shown that there are only intentions of overcoming the barriers established in

Table 15: Cash flow by sale of energy remnant by agreement ANDE proposal.

Description		Year zero	2014	2015	2016
Income per sale (PLD max)			1,132,567,516	1,618,299,193	630,520,618
Cost of energy IB			-198,428,000	-182,924,400	-180,348,000
Other expenses	Income tax		-140,120,927	-215,306,219	-67,525,893
	Contribution PIS+COFING		-41,338,714	-59,067,921	-23,014,003
	Staff and other		-72,000	-72,000	-72,000
	Compensation Py		-50,529,232	-53,880,685	-55,085,742
	CCEE and others	-10,000	-372,000	-372,000	-372,000
	Patrimony (ANEEL)	-310,000			
Subtotal		-320,000	701,706,643	1,106,675,968	304,102,980
Tax IOF		-32,000	-70,170,664	-110,667,597	-30,410,298
Utility		-352,000	631,535,978	-996,008,371	273,692,682

the Treaty of ITAIPU for the commercialization and better use of Paraguay's surplus in hydropower.

The answer to seek alternatives to commercialize ITAIPU's energy under conditions different from those imposed by the treaty and related agreements can be found in the Lula-Lugo Agreement signed in 2009, at point 6 which states "They recognize the convenience of ANDE being able to gradually, as soon as possible, commercialize in the Brazilian market energy corresponding to Paraguay's acquisition rights". Although this point expresses a circumstantial political will, it must be taken into account that it was not carried out. However, it has the importance of having placed the issue on the negotiating agenda of the two partner countries and can be used as a precedent to establish bilateral agreements that remove barriers to the commercialization of energy in the Brazilian electricity market, within the framework of the rights acquired by ANDE in the ITAIPU contract.

On the other hand, it was possible to demonstrate that the Lula - Lugo Agreement is in force (in only certain points) and that the financial benefits of the implementation, under the conditions that were analyzed in this work, are high. The results obtained in this study indicate that it would be very convenient for ANDE (or for the Paraguayan State) to consider the installation of a commercialization company in Brazil.

With the financial analyses it was demonstrated that in the cases of sale of energy associated with surplus power and remaining energy (not used for internal market) associated with increases in power contracting by ANDE, high revenues would have been obtained from direct sales in the Brazilian market (period 2014-2017). These values would be much higher than what is currently transferred as an assignment, receiving only the compensatory payment for energy assignment of about 9.34 USD/MWh.

In the case of sale of surpluses, it would not be necessary to make an initial investment other than the concepts of contribution to the CCCEE and the basic expenses considered in this study; this situation, considering a period from 2014 to 2017, could have a Net Present Value (NPV) of approximately USD 950 million. However, in the analysis of the proposal where if ANDE had increased its contracted power in the period 2014 to 2016 and sold its surplus energy in the short-term market, this would have an NPV of about two billion dollars, all values were transported to the year 2,017.

With these values, it is reiterated that the Lula - Lugo Agreement can open the possibility of maximizing benefits for the State by commercializing the remnants of electricity in the Brazilian electricity market. ANDE could even count on an additional source of income to reduce its need for external financial resources. It should be remembered that the necessary investments included in the 2016-2025 Master Plan are high and largely without guaranteed financing.

The results of this work could be useful for the national government to make decisions that are relevant to the energy sector: i) the creation of a Ministry of Hydrocarbons and Energy (as stated in Energy Policy 2040, approved by Decree No. 6092/2016 of the Executive Branch) that collaborates with the Ministry of Foreign Affairs in advancing negotiations that take as a precedent the Lula-Lugo Agreement; and ii) the creation of a commercialization company in Brazil with the purpose of commercializing the energy that corresponds to

Paraguay with the aim of generating greater economic benefits with a view to promoting Paraguay's development.

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Conflict of Interest
There is no conflict of interest.

Supporting Information
Not applicable.

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