

Ecuador as an Exporter of Electricity

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Abstract---*In this article, an analysis is made on the sale of the electrical energy made by Ecuador to other countries, also mentioning the beginnings of the electricity market in the country. The hydroelectric projects built in the last decade are described, which are the ones that will guarantee the export of the energy resource. There is talk of the amount of energy that is exported in MWh, to the countries of Colombia and Peru, as well as the limitations that have arisen in the infrastructure when sending the energy. There is also talk of the benefit that the sale of electrical energy brings to Ecuador and the profit that this implies. The objective of this article is to make known how the sale of electrical energy from Ecuador to other countries is carried out, and how much it enters the country as a profit for it, in addition to analyzing the current situation as energy exporters and looking for possible solutions in case of find difficulties or deficiencies.*

Keywords--- *demand, energy, ex-contribution, generation, transmission.*

Introduction

Electricity is an indispensable part of humanity's natural development, in industrial, commercial and residential terms. Electricity generation is obtained through other primary sources of energy in which two types are distinguished: Renewable and Non-Renewable Sources. After this stage, the electricity produced is distributed using electrical power transmission systems, which can be high or low voltage, to finally, in a third stage, reach the consumer through distribution networks (Olade, 2014).

Electricity is an input of vital importance to the economy as it is used practically in the production of all goods or services, as well as in the daily activities of anyone. The demand for electricity has grown rapidly, along with technological development and the advancement of computer and communications systems. Therefore, per capita, electricity consumption is in direct proportion to economic development (Brown del Rivero, 2011). Technology is advancing in leaps and bounds, and increasing energy requirements are increasing, so demand is increasing in an accelerated way.

The current energy landscape in Latin America and the Caribbean shows that total electricity consumption in the region rose from 489 TWh per year in 1990 to 1,073 TWh in 2010, representing an average annual growth rate of 4%. The region's average electricity coverage is 88.6%, or approximately 66 million people do not have access to electricity. Brazil, Chile, and Costa Rica have electricity coverage over 99% while countries such as Haiti and Nicaragua have percentages of 34% and 65% respectively, considering areas such as design, planning, regulation, operation, efficiency, marketing, environment, among others (Olade, 2014). It can be noted that there are still many people who cannot access electricity, so it is of paramount importance to work on the construction of electricity networks so that each time these numbers of people who cannot access electricity are decreased, as it is a basic service that every human being should have (Lund, 2007; Hall & Bain, 2008; McDonald & Schrattenholzer, 2001).

Within the region, Brazil is the main producer of electricity, with a generation, during 2010, of 516 TWh; the countries that follow it are Mexico Argentina, Venezuela, Chile, Colombia, among others. On the other hand, Paraguay is the largest electricity exporter reaching, in 2010, exports to 43.4 TWh to Brazil and Argentina with which it shares two large hydroelectric plants such as Itaipú and Yacyretá respectively. For its part, Brazil is the largest net importer in the region with figures reaching 35.9 TWh in 2010, Argentina is the second largest importer with 10.3 TWh (Olade, 2014). We have to take reference to developed countries in the energy area, and take as an

example their actions, and apply them in our country, Brazil is the country that has invested the most in infrastructure to generate electricity, before that they had constant blackouts because they could not bear the demand that the country needed at the time, the electricity service was intermittent. Being a country with great water potential was thought to take advantage of it and create several hydroelectric plants, among them the Itaipú hydroelectric plant, which can generate 14000 MW, and is considered the second largest in the world, after the 3 Gorges Hydroelectric Power Plant located in China that generates 22,500 MW.

Materials and methods

For the realization of this article, the method of bibliographic review was used, based on the search for information from various sources, which are all duly referenced and cited; in addition to the deductive inductive method.

Analysis and discussion of the results

History of the electricity market in Ecuador

The year of 1897 has a great historical significance in the development of Ecuador's electricity sector, as it was the starting year in which the electricity service is made available to the needs of the public (INECEL, 1978). It was the year of 1897 when Loja, the southern city bordering Peru, decided to bring to life the first electric power plant that was built in Ecuador: the Electric Company Luz y Fuerza, today Regional del Sur (Universe, 2007).

The plant, armed on the Malacatos River (Loja), was born with two hydraulic turbines of 12 kW each, enough to clarify the night (Universe, 2007). The first electricity distributor emerged with a share capital of 16,000 sucres (which today would not reach a dollar). That investment came from a group of lojanos determined to form the company. They did so on April 23, 1897 (Universe, 2007). Loja became the first city in the country and the third in Latin America, after Lima (Peru) and Buenos Aires (Argentina), to have electric service for the next 20 years (Universe, 2007). One of the first cities where electricity was regulated in some way in the country was Guayaquil, due to the great demand that existed in that city at the time, and the great economic power that entails that.

On October 29, 1925, the Very Illustrious Municipality of Guayaquil signed a concession contract to distribute and commercialize electricity in Guayaquil for 60 years., in its eighth article, it imposes a minimum commitment: to install a small power plant in Bucay and diesel engines in Guayaquil. The commitment that was never fulfilled, In exchange for the tax rights and exemptions guaranteed by the contract, EMELEC had to pay to the Council - during the term of the contract - 2% on the sum it receives as a gross product from the electricity for ministers (Peralta, s.f.). Subsequently, in 1926, the Government of Ecuador signed a 60-year contract with THE AMERICAN FOREIGN POWER CO., for the supply of electricity to the city of Guayaquil. Similar contractors were made for service to other cities in Ecuador such as Quito and Riobamba (INECEL, 1978).

Capitalizing on such an Initiative, and in the face of the growing interest of citizens throughout the country to have electricity as a public service, the Municipal Regime Act of 1,945, assigns the different Municipalities the responsibility to meet the needs of electricity services, as well as that of drinking water, sewerage, telephones, etc., within their respective legal (INECEL, 1978) areas. The result of this management was that at 1960 the total amount installed in Ecuador at 120,000 KW, distributed in 1,200 power plants with an average of 100 KW per plant and a media electrification index of 25 watts per inhabitant, the lowest among the countries of South America in that year or, just supplying the much or the demand of its corresponding urban center not in rather poor technical conditions. However, it should be noted that the installed power in the period 1932-1960 grew with an average annual cumulative rate of 11.3%, starting in 1952 with 51,141 KW installed (INECEL, 1978).

In this illustrative retrospective, the year 1961 marks a reversal with the governmental decisions taken, initiating a broad policy of integration of the electricity sector of the country, which will lead to the formation of the various Regional Electric Siste, In that year, by Decree-Law of Emergency No. 24 of May 23, the Ecuadorian Institute of Electrification (INEC) was created. Institution responsible for integrating the electrical sector of the country, and developing a National Electrification Plan that meets the external energy needs demanded by Ecuador's Economic and Social Development (INECEL, 1978) Plan.

The management of INECEL (Ecuadorian Institute of Electrification) has 3 stages marked in its history. The first from 1965 to 1970 in which the first collection of hydroelectric information and a census of the electrical installations also the first master plan of electrification seeking the integration of regional systems, the creation of a

National Interconnected and the development of a Rural Electrification program. In its next period from 1970 to 1980, the National Interconnected System was already in operation with the entry into operation of generation plants and transmission systems, all financed by resources by oil exploitation and by external indebtedness. During the years 1996 to 2007, the Law on the Electricity Sector Regime generally mentions that the main purpose is to provide the country with high quality and reliable electricity service that guarantees economic and social development.

The electricity sector had economic and financial autonomy. INECEL retained its legal capacity until 1999 where its competences are transferred to the Ministry of Energy and Mines (CIFUENTES, 2017). On March 10, 1966, he authorized the Ministers of Finance and Industries and Commerce, forcing the Government of the Republic, with the persons of the Ecuadorian Electric Company Inc. in the conclusion of a contract by the following dollars or stipulations: a guaranteed net return of no less than 9.5% and not more than 10% per year on their net capital invested in Dollars. EMELEC then became the only business in the country that by law could not lose. Also, according to this document EMELEC was authorized to keep its accounts in Dollars. These are among other provisions that made EMELEC a privileged company" (Peralta, s.f.). It clearly shows us how far the submission of this nefarious government to American interests led to great economic losses (Nold, 1980; Morris & Kretzschmar, 1995; Gopalsamy & He, 1994; Mace, 1984).

Between the 1980s and 1990s "The electricity sector in Ecuador lost about USD 15.6 billion due to technical and administrative inefficiencies in its generation, transmission and distribution plants. Also, an estimated \$3 billion was eliminated due to debt forgiveness and \$2,000 more were earmarked to pay the (Flowers, 2011) tariff." In Ecuador, most of the problems had to be faced by the government of León Febres Cordero, which took over a struggling country, with a deficit of 7.5% of GDP, average inflation of 40% and a Sucre that experienced a devaluation of 40% per year. Added to this is the low price of the barrel of oil (USD 20 (Flowers, 2011) average). This caused a major crisis in the Ecuadorian electricity market, which led to large economic losses both with the problems of generation, transmission, and distribution as well as large inefficiencies in the service of electricity, which generated the more lost, this is a problem of miscalculation in tariffs which caused a large monetary deficit.

Energy export

Exports or imports of electricity are made by economic optimizations, in the case of Ecuador and Colombia, or Ecuador and Peru, both countries have electricity, but one of them has cheaper energy, so instead of producing their energy, they buy from the other country with cheaper energy. According to data from the National Energy Balance of the Coordinated Ministry of Strategic Sectors, for 2015 in terms of power, Ecuador has more than 5,000 MW of installed capacity: 56% thermal; 42% hydraulic; 0.5% solar and 0.4% wind. In terms of electricity, 14,266 GWh was consumed: 49.1% from thermal power plants; 45.6% hydraulics; 1.6% biomass; 0.3% wind and 0.1% solar. The remaining 3% corresponds to electricity imports from Colombia and Peru. This indicates a predominance in the consumption of fossil sources within the national electrical matrix. In terms of thermal generation, several transformation technologies are available such as turbo steam (thermodynamic steam cycle); turbo gas (thermodynamic gas cycle) and internal combustion engines (Otto and Diesel thermodynamic cycle), as each takes advantage of different fossil fuel; the most commonly used are fuel oil 40.8%; natural gas 20.3%; 19.9% diesel; oil 8.5% and cane bagasse 6% giving a total of more than 22,000 kBEP (kilo barrels of oil equivalent) (Constant, 2016). This amount of fossil fuel used will be significantly reduced when all hydroelectric plants being built come into operation.

Since February 2016, Ecuador began exporting electricity to Colombia continuously with daily volumes, which have reached peaks of up to 7000 MWh with a daily average of 2500 MWh. (ARCONEL, s.f.). If we compare the amount of energy that will be sold to Colombia with the amount of energy that will be sold to Peru, the energy to Colombia will be higher, due to. The need for further work has been mentioned for regional electricity interconnection and the formation of a regional electricity market, with particular emphasis on the Andean Electric Interconnection System (Sinea) and the Andean Community (CAN) (The Republic, 2014). Another long-term goal is to have a network of interconnection between all Latin American countries, to export or import electricity according to the requirements, an ambitious project, which will need many millions of investments among all the countries involved, but at the same time will bring great benefits.

As of May 2016, Ecuador exports energy to Peru through electricity purchase and sale agreements established with power companies in Peru. So for the first time, there is the simultaneous export of electricity to Colombia and Peru that seeks to take advantage of binational electrical interconnections (Gamez et al., 2016; Monier et al., 2019). For the first time in Ecuador's history, we have become exporters of electricity, however, it must be analyzed that we do not have the necessary infrastructure, and adequate to be able to export electricity to Peru as required, the limit is not the voltage generated, but the power transmitted, the line connecting Ecuador and Peru supports only 90 MW,

which is the power necessary to be able to solve the demand of the city of Machala at half-day times, as an example (ARCONEL, s.f.).

Until August 2016 Ecuador sold to Colombia energy for about USD 40 million, that, said by the Minister of Electricity, Esteban Albornoz, point out that in a week another hydroelectric plant would be inaugurated in the south of the country, the Sopladora plant, located in the province of Azuay, with new hydroelectric plants, will cover the demand of the country with clean and friendly energy with the environment, and it will have the energy capacity to be able to sell to neighboring countries (Starobinsky, 1982; Ishida *et al.*, 1987; Bridgwater, 1995). The Sopladora hydroelectric plant, whose construction demanded an investment of \$755 million, will save Ecuador about 280 million, by replacing the consumption of oil and the production of electricity, on an installed capacity of 487 megawatts of power, Blower will also avoid environmental pollution, since it would equate to taking out 380,000 vehicles and prevent the emission of 1,090,000 tons of carbon dioxide into the air.

The Ecuadorian government at the time mentioned the possibility of granting this power plant to the private sector, they also mentioned that there were several companies concerned, favorably not given, and nothing has been mentioned about it at present. Ecuador and Chile signed an energy agreement that seeks the creation of the Andean Energy Corridor, which will allow our country to export energy to different South American (Presidency of the Republic of Ecuador, 2018) countries. This will be of great importance to Ecuador's economy, it will be yet an alternative to improving income to the coffers of the Ecuadorian state. Albornoz, Minister of Electricity of the Government of Rafael Correa, said that Ecuador wants to sell electricity to Chile, given the electricity surplus projected in the country for the period 2017-2020, while Pacheco highlighted the commitment of both countries in this area (The Republic, 2014). This project will help strengthen the economy of both countries.

The agreement between the two countries consists of six points that were analyzed over three years, said Máximo Pacheco, Chile's energy minister. Both countries are working (Presidency of the Republic of Ecuador, 2018), to make export so that they make a profit between the two parties. Esteban Albornoz, Minister of Electricity and Renewable Energy of Ecuador, of the government of President Rafael Correa indicated that it is looking to have an interconnection line of 500 thousand volts. This wiring will start from Ecuador and then cross the countries of Colombia, Peru, Chile, and Bolivia. These are previous work that must be carried out, to be able to transport electricity to these countries, with the line to be built, the objectives will be achieved (Presidency of the Republic of Ecuador, 2018).

This has been achieved thanks to the operation of the Coca Codo Sinclair plant in its first phase of 750 MW and the first tests of the 487 MW Sopladora plant, substantially increasing energy production from renewable sources, which make export feasible. (ARCONEL, s.f.). The power generated in the Coca Codo Sinclair hydroelectric plant is only 50%, that is, only half of the nominal power, with that figure at that time, was generating 80% of the country's energy, with renewable sources, it is said that when Coca Codo is operating at 100%, the amount of generation from renewable sources will increase to 90%. The cost of building the hydroelectric plant in mention was 2245 million. In the middle of 2016, the country had three power stations (Manduriacu, Sopladora, and Ocaña) and five to open in a few months, according to the government at the time Ecuador will save more than 1 million dollars each year, who at the same time called that Ecuador imported energy before, while today we exported it. "With the 8 hydroelectric plants we will avoid emitting 6.29 million tons of CO₂ annually, equivalent to what would contaminate 1.2 million light vehicles," he explained (Policy, 2016).

From the construction of hydroelectric projects, in addition to saving a lot of money, we will stop polluting the environment, which is something that should be considered today, is something that we should not overlook since we are closer and closer of the destruction of our planet because of so much pollution that we cause. In August 2018 and the President of Ecuador, Lenin Moreno, met with his Chilean counterpart, Sebastián Piñera, in the neighboring country of Colombia to address issues related to Andean electrical interconnection, the Llurimagua-Codelco mining project, investment treaties and air connectivity. The meeting took place on the occasion of the presence of both Mandatarios in Bogotá to participate in the investiture ceremony of the new president of Colombia, Ivan Duque. This hearing analyzed the state of the Andean Electric Interconnection System (Sinea), which will allow Ecuador to export energy to Chile in the future, for which joint tasks must be implemented.

These actions seek to position the country as a potential clean energy exporter in the region (Telegraph, 2018). The government of President Lenin Moreno, looking for new ways to enhance Ecuador's economy, the projects they seek to concrete will help on ways to improve the economy of the country and will employ a significant sector of the Ecuadorian population, at the end of the mining project in the Province of Imbabura. Ecuador bought electricity again from Colombia; they confirmed it from the Ministry of Energy, stating that this is a consequence of the lack of rain (Monroy, 2018). Since October of 2018 energy is imported, around 2000 MWh, in the absence of rain it becomes difficult to generate hydraulics to supply national demand, the other alternative that we have as a country is

a thermal generation, but this type of generation is expensive since the principle of operation is the burning of fossil fuel, which in addition to being an expensive option, is a highly polluting alternative, in this situation, is more economical buy energy, to produce it thermally in our country.

Valuations

In carrying out this investigation, Ecuador's limitations as an exporter of electricity were known, as well as the revenue strenuite since 2016 as electricity exporters. It has also been known that some large generation works are partially functioning due to construction failures, which warrants the immediate repair of them, which represents economic losses, not only due to lack of production but also required a large amount to repair the damage that has been found.

Corrections are currently being made and at the same time seeking to improve ace to propose projects that will strengthen bilateral relations, from Ecuador between the countries of Colombia, Peru, and Chile. Another difficulty is that the construction of the transmission lines is still missing, so the generated energy cannot be sent. It should be mentioned that at the end of 2018, Ecuador no longer exports electricity, due to several factors involved in hydroelectric generation, mainly the section through which the country is going, the situation is expected to reverse, and it will start again Ecuador to sell electricity and generate economic revenue.

Conclusions

Ecuador has had considerable revenues from electricity sales to neighboring countries, but it has been partially, not in a constant way as would be expected. Currently to be a consolidated country as an exporter of electricity is missing a lot. The emblematic prheycos on which the idea of selling electricity is based, have presented several structural problems, what has caused partial stops is several of them, also, some are unfinished.

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