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The local energy development with hydraulic energy in the province of Manabí Ecuador

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Abstract

In the province of Manabí, the challenge proposed by the energy strategy has not yet been met, especially in rural areas where it is more difficult and expensive to extend the lines of the electrical system, despite the efforts, the required quality of service is not achieved , with a negative impact on meeting the needs and socioeconomic development of rural regions. The high performance obtained in the transformation of hydro energy into electricity, contained in rivers and water courses, is very high. That is why this energy source is used almost exclusively in the production of electricity. Hydroelectric plants have very different applications depending on the energy needs that exist in the area where they are installed, although they are mainly used to generate electricity to sell it to the grid later. In the work, the results of a study of the hydraulic potential of the Coaque River are presented, to be used for energy within the framework of local development, for which 12 communities that are close to the riverbed and where capable technologies could be used were made visible. to take advantage of the small existing potential in order to improve the quality of the electricity service, save natural resources and contribute to the reduction of COemissions$_2$ into the atmosphere. Data series are presented in tables that allow to analyze the result of the study of the hydraulic potential in 12 sites studied in the Coaque River and its possible link in terms of benefiting the population that resides near these points.

Keywords: *flow; location; endogenous resource; river*

1. Introduction

Studies on science have been paying increasing interest to its social dimension and the use of endogenous resources in localities. The incorporation of technologies further accentuates the interest in social studies, which is increasingly focused on the study of science in the process of production, dissemination and application of science…"(Núñez, 2002. P. 461).

Since the Neolithic era in ancient times, man begins to use energy at will in agriculture, including the use of animals for work, especially in agricultural tasks. During the IV and III centuries before our era, the first energy systems were explored, with the construction of the first crop irrigation systems taking advantage of the current of rivers such as the Tigris, the Euphrates and the Nile (Vázquez, 2013).

Mastering the hydraulic potentials of rivers is among the first five sources of energy that were used by man, along with his own muscles, that of domesticated animals, firewood, and the wind. For millennia it was these sources that made the development of human society possible.

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The spectacular leap in energy matters occurs between the years 1860 and 1930, when the second industrial revolution takes place. During the first industrial revolution between 1760 and 1840, the use of coal had displaced wood. The major developments associated with the introduction of electrical systems, aviation and the steel industry, demand a more powerful and concentrated energy carrier, and mineral coal gives way to the preferential use of oil. By the first years of the 20th century, this fossil fuel had become the preferential source of energy, which implied its increasingly extensive and intensive use (Berris, 2010).

During the first half of the 20th century, oil prices were low. Power generation had low costs, so electricity service was economically affordable. In the second half of the twentieth century, the first oil crisis took place and from that time to the present, oil prices have increased gradually and constantly, with a very marked cyclical instability in the behavior of the prices of this source of oil. Energy. All of this has led to current energy generation having high costs that make the system unsustainable from an economic point of view (Vázquez, 2013).

To all this we must add that it was not until the second half of the 20th century that the serious damages associated with the intensive use of fossil energy sources, especially oil, were discovered and scientifically demonstrated.

From the realities analyzed above, we begin to look for energy alternatives that are sustainable that are at the same time respectful with the environment, considering the right of future generations to enjoy the benefits of nature and a healthy environment.

It is based on the criterion that the results of the investigation on the flow of the Coaque River, promote the use of endogenous energy resources for the improvement of the electricity service and the living conditions of the communities that are located on the banks of the river, also representing a contribution to the preservation of natural resources and the reduction of COemissions$_2$ into the atmosphere.

The objective of the work is to show the results of a research project on the study of the energy potential of the flow of the Coaque River, in the province of Manabí, in order to be used for the contribution of energy to the national interconnected system of the Ecuador, with a vision of local development.

2. Materials and methods

The type of field research was put into practice, with the aim of using the scientific method, to obtain new knowledge related to the socio-energy profile in the Coaque River, which allowed diagnosing the needs and problems that arise with the electrical service in the communities that are located near the studied sites (Hernandez, Fernández, & Baptista, 2010).

The research is of the qualitative type as it is carried out through the description and compilation of socio-energy data, which helps to explain the problem, as well as the behavior of the parameters measured on the energy potential in the Coaque River. The criteria and experiences of the interviewed specialists, as well as those surveyed, are transmitted, helping to understand the research problem and the importance of the study being carried out (Hernandez et al., 2010).

To measure the potentials in the river, the gauging technique was put into practice, which is one of the simplest ways to carry out the study. The results obtained allowed us to deepen the evaluation of the hydraulic potential that can be used for the generation of electricity in the Coaque River (Corantioquia, 2014).

In addition to this, other techniques were combined such as: observation as a basic research technique, which allowed to investigate, discuss and conclude on the energy problems that exist in the studied communities; specialized interviews with experts with knowledge of power generation through water potential, which allowed establishing an approach to the technologies that can be used to take advantage of the small energy potentials that exist in the river; surveys of the inhabitants of the studied communities,

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which made it possible to obtain relevant data that allowed to confirm the hypotheses drawn (Hernandez et al., 2010).

The instruments used were: the observation guide; the agenda for the specialized interview; the questionnaire for the survey and; the technical file made in each community visited.

The population for the study has a dimensionless value, so to define the sample for the surveys it was necessary to apply equation (1) (Vargas, 2014), (Bolaños, 2012).

$$n = \frac{(Z^2)\,PQ}{E^2} \qquad (1)$$

Where:

Z^2→Confidence level (1.96)

n→sample size

P→Probability of occurrence (0.5)

Q→Probability of non-occurrence (0, 5)

E→Acceptable limit of the sample error (0.01)

Resulting that the sample was made up of 96 citizens residing in the rural communities studied.

To carry out the work, 12 points of the river that are close to the communities were selected. Table 1 shows the selected communities and some data of interest for the research.

Table 1. Communities selected for the study

Informative data Site / Community	**Distance of the Community to the river (m)**	**Number of**		**economic and socialEntities (U)**	**Calculation energy demand power (kW)**	**Quality service electrical**
		Casas (U)	**Persons (U)**			
Achiote	100	53	292	4	938	Regular
Atahualpa	250	113	565	11	2000	Regular
El Ají	100	20	100	1	200	Regular
Cañaveral	100	43	215	3	761	Good
August 5	180	98	523	8	1734	Good
Taviaza Down	100	14	70	1	248	Good
10 de Agosto	50	73	438	10	1292	Good
Santa Rosa	50	37	185	4	655	Good
Hacienda el Rosario	150	19	105	2	336	Good
Quiauque Arriba	250	16	96	2	283	Regular
Cholote	250	34	187	2	602	Regular
Baloy	50	18	90	1	319	Regular

Source: Elaboration own based on data from: (De la Cruz & Zambrano, 2017)

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3. Analysis and discussion of the Results

Currently more than 60% of the energy generated in Ecuador has a hydraulic origin, structured in large power plants that are located in its majority in the Sierra region (Lic ango, 2013). However, in the Manabí province the basic generation source is constituted by three thermal plants and a symbolic contribution of photovoltaic energy. In a technical environment, the cost of the kWh generated is high and with high levels of COemissions$_2$ into the atmosphere (Hernández and Vera, 2018).

Hydraulic energy is cheaper than the average price of thermal energy, in addition to the environmental benefit that the implementation of these projects entails as it is clean energy. When hydraulic projects are large, they can cause significant impacts on the environment; But when small water use systems are introduced, they turn out to be manageable and significantly reduce the associated environmental impacts.

Figure 1 shows the distance from the communities to the river and the number of dwellings in each of them.

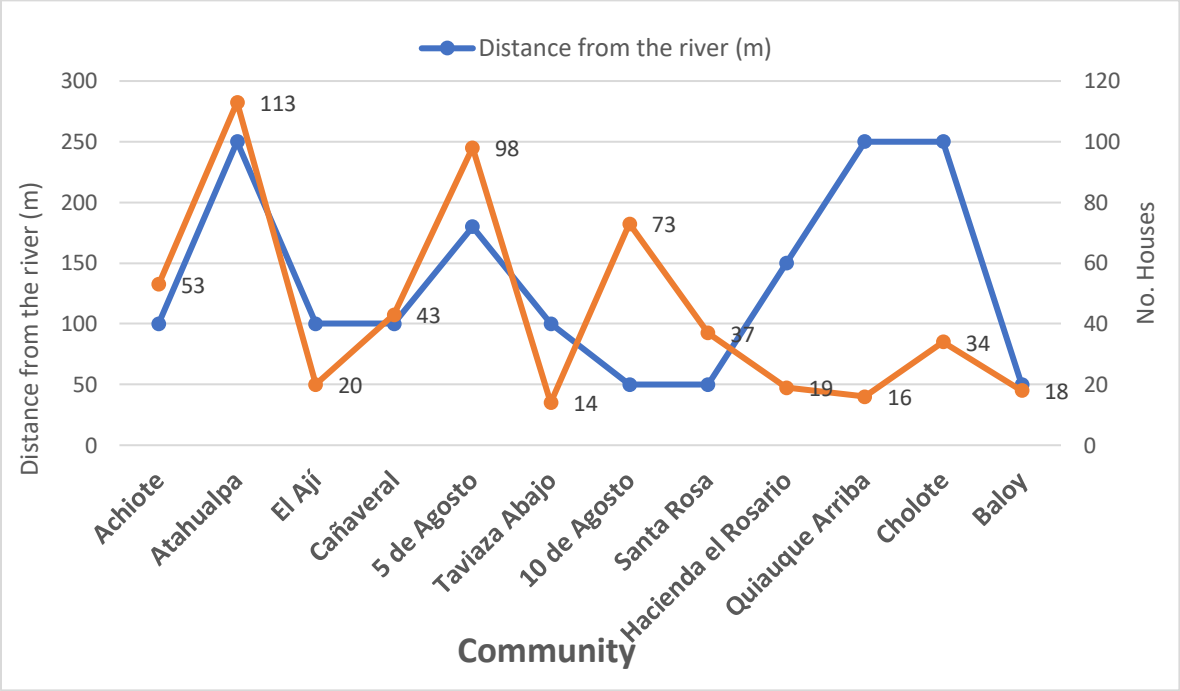

Figure 1. Distance of the communities to the river and number of houses

As can be seen, the communities furthest from the river have fewer houses, and different factors can be analyzed, for example the houses that are closer to the river, solutions could be sought energy companies in a small format with a social impact by improving the quality of energy where the service is regular, such as the communities of Achiote and Atahualpa, shown in table 1, in the case of the most remote such as Quiauque Arriba, Cholote and Baloy, alternatives can be sought with other renewable sources such as photovoltaic solar (Rodriguez, Vázquez, Velez & Saltos, 2018).

On the other hand, in recent decades the development of rural areas in the province of Manabí has been marginal from the energy point of view, which has impacted on the progress of agricultural areas and the very quality of life of the inhabitants, mostly from poor strata. Currently, more than 5% of the Manabi population does not have electricity services, mainly in rural areas that are far from generation centers (CONELEC, 2010).

In the territory of the Manabi province there are several rivers that run throughout the year, among which is the Coaque River, which can provide small potentials of hydraulic energy with the possibility of being

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used in the generation of electricity. This would make it possible to solve problems associated with rural electrification or as an energy contribution to the national interconnected system, contributing to saving natural resources and reducing emissions of polluting gases into the atmosphere.

However, it is not known that until now studies have been carried out on the calculation of the hydraulic energy potential in the Coaque River, so it is very difficult to estimate its potential in terms of generating energy and thus contribute to the improvement of the living conditions of the people who reside on its margins.

The Technical University of Manabí is an institution of higher education in Ecuador, which works in the search for sustainable solutions to the energy scheme and for this it proposes to carry out the study of the potential of renewable sources in the Manabi province, within which they are the small hydraulic potentials that exist in the Coaque River, focusing the solution on improving the living conditions of the rural population that currently does not have electricity service and in others where the service is received with very low quality. Figure 2 shows a map of the points where the river gauges were made.

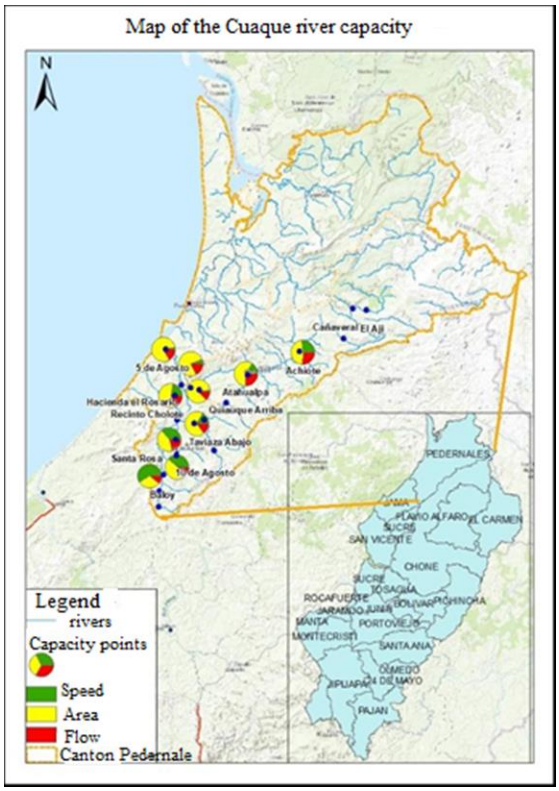

Figure 2. Map of gauged points

In each study site that is close to the communities, a survey was carried out of the electricity demand that existed in each community, being able to make a graph of this and the values shown in figure 3, as can be seen in the points measured in the communities with lower installed power, they have higher flow rates, and it is interesting to make reflections regarding the possibility of implementing some hydraulic generation technology to satisfy the needs, taking into account that the communities are among those that have a regular power quality.

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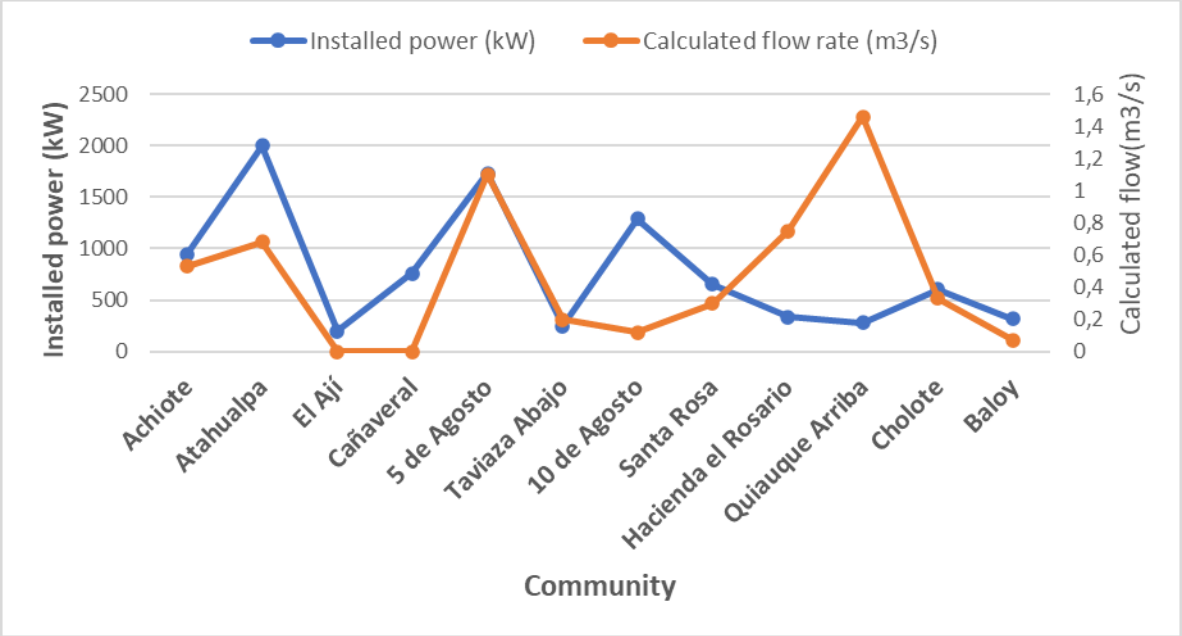

Figure 3. Installed power and calculated flow

The higher education institution is committed to venturing into the study of technologies based on small water generation systems that can enhance the energy use of the Coaque River, which is considered one of the main sources of water at the level of the province of Manabí.

To give an idea, it can be analyzed that the territory of the province reaches abouthm^3 6,270of water, a value that corresponds to 545.1 mm of average annual runoff, where the Coaque River has the maximum annual volume of runoff, equivalent to 1 913 hm^3, with 30.5% of the total demarcation.

Through the execution of the project, it was possible to carry out the study of the flow of the Coaque River, in order to promote a community intervention in the energy order, to improve the living conditions of the inhabitants of rural areas who reside on the banks of the river, in line with what is stated in the National Plan for Good Living, which states:

> "In parallel to the execution of large hydroelectric projects, in 2030 the supply of electricity will be complemented by the implementation of small projects of power generation with renewable sources such as: photovoltaic, wind, biomass and hydroelectricity in areas close to consumers, and with participatory management schemes of Decentralized Autonomous Governments, community organizations and the private sector "(Senplades, 2017).

It is necessary to recognize that these projects based on the use of renewable energies for local productive uses and the interconnected system, allow generating local employment, optimizing the use of natural resources, diversifying the territories in the generation of electricity and reducing technical losses in the transmission of electricity.

3.1. Results of the survey

During the work, 96 surveys were carried out and the results were tabulated and quantified. The objectives were focused on obtaining information regarding the importance given to it by the inhabitants of rural areas who reside in sites close to the potentials studied in the Coaque River, on electricity service, efficiency and energy savings, as well as the role that hydraulic potential can play in meeting electricity demand, improving service and contributing to environmental protection. The statistical results of the surveys are reflected in table 2.

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Table 2. Results of the surveys

No question	Content	Results			
		High	Medium	Low	Very low
1	What role do you give to the electric service?	42	27	27	0
2	At what level do you consider the quality of electricity service in the area where you reside?	37	27	16	16
3	At your discretion. What level is the management provided by the electricity company in maintaining the quality of the electricity service?	16	53	16	11
4	Do you consider that electricity service can be improved in the area?	27	53	11	5
5	What is your notion about the possibility of generating electricity with river water?	0	0	32	64
6	In your consideration, what role could the river's hydraulic potential play in improving electricity service in the area?	0	9	28	59
7	In what measures do you consider that the use of the river's water energy can contribute to saving resources and efficiency?	0	0	43	53
8	In what measures do you consider that the use of the river's water energy can contribute to the protection of the environment?	0	0	21	75
9	To what extent do you consider that the use of the river's water energy can contribute to the social development of the area?	0	0	37	59
10	How do you consider the vitality of the river flow to generate electricity?	0	0	51	45

Source: Own elaboration based on data from: (De la Cruz & Zambrano, 2017)

The surveys made it possible to specify the following questions:

Despite the fact that the studied communities receive the electricity service of the national interconnected system (SNI), the population interviewed does not have an adequate notion about the important role that the electric service can play in terms of raising the quality of life of the population, since it is very difficult to locate any modern activity in society where it is not required electricity service.

The results of the surveys allowed to verify that the quality of the electrical service in the area does not behave in a homogeneous way. The main problems are concentrated in the El Achiote, Atahualpa, El Ají, Quiauque Arriba, El Cholote and Baloy communities. The electrical service of the SNI reaches all the sites; but they are distant from the generation centers and the power lines run through rural areas that in some cases are intricate, where there are great losses of energy.

It was found that the management provided by the electricity company in maintaining the quality of the service in the area, presents a situation similar to the quality of the service. The situation can get worse when the winter rains arrive, where interruptions are more frequent and there is a longer delay for their solution by the electricity company.

It was found that despite the lack of knowledge of the population regarding the way in which the quality of electricity service can be improved, in the most affected communities it is suggested that something more can be done, since in other areas it has been possible to improve the quality from service. On the other hand,

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there is a minority that is unaware of the potential of renewable sources that exist in the area and therefore argue that the possibilities are low or very low. The most pressing situation is faced in the communities: El Achiote, Atahualpa, El Ají, Quiauque Arriba, Recinto El Cholote and Baloy.

It was found that an important part of the surveyed population is unaware of the possibilities of the river's hydraulic potential in terms of improving the quality of electricity service in the area, as well as the possibility of saving natural resources and achieving greater energy efficiency.

The research made it possible to define the ignorance of the surveyed population, regarding the potentiality of electricity generation represented by the river water, which is close to the localities where they reside. It is unknown that there is currently a wide range of technologies based on micro and pico centrals for domestic use, which allow obtaining the electrical energy necessary to satisfy the consumption of a house. It is ideal for isolated country houses that have a small flow of water, making it possible to obtain powers of 1, 2 and 3 kW and to take advantage of residual energy to heat water for domestic use. This is a situation that needs to be known by the inhabitants of the affected areas.

It was found that the surveyed population is unaware of the possibilities offered by energy generation by taking advantage of the river's hydraulic potential in order to reduce the environmental impact derived from electricity generation. For every MWh of hydraulic electricity that is incorporated into the electrical grid, the emission of 0.9 tonnes of COcan be avoided$_2$. On the other hand, the contribution that the use of hydraulic potential can make to improve the quality of the service and thereby increase the social and cultural development of the area is unknown.

The surveyed population considers that the Coaque River does not have vitality to guarantee the generation of electrical energy and in that sense it can be argued that it is true that the river does not have a hydraulic potential that can be considered important, maximum when the research has been developed in the dry season; but currently there are technologies that allow to take advantage of the power that may exist in the small flows and thus be able to contribute to saving resources and improving the quality of electricity service in the areas studied.

Synthesizing what was previously analyzed, it can be argued that the survey allowed to verify that there is much ignorance on the part of the population related to the real possibilities of the river flow to solve the energy problems that arise in the studied areas, being a situation that needs to be addressed by local authorities.

Through the investigation, 12 sites of the Coaque River were studied, which are of interest for the analysis on the possible use of the hydraulic potential for the generation of electricity, since they are located in places near populated areas where, in addition to the citizens who can be benefited , there may be objectives linked to trade, production and education. Table 3 shows the result of the river flow measurement.

Table 3. Results of river flow measurement

Sites studied (community)	**UTM coordinates**	**River depth River**	**width**	**Area**	**Flow**
		(m)	**(m)**	**(m^2)**	**(m^3/ sg)**
Achiote	79 ° 53 '40.45 " W-0 ° 0 " 14.26 " N	0.16	6	0.97	0.53
Atahualpa	79 ° 57 '59.27' 'W-0 ° 1' '33.82' 'S	0, 15	10.3	1.53	0.68
El Ají	79 ° 47 '53.32' 'W-0 ° 3' '49.89' 'N	It was not possible to measure theflow			

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Cañaveral	79 ° 49' 3.60 " W-0 ° 3 " 57.82 " N'10.47' 'W-0 ° 0' '28.31	It was not possible to measure the flow			
August	5 80 ° 5' 'N	0.30	17.5	5.25	1.11
Taviaza Down	80 ° 2 '34.22' 'W-0 ° 5' '58.65' 'S	0.08	11.4	0.90	0.20
August 10	80 ° 4' 21 , 25"W-0 ° 8 " 40.86 " S	0.09	4.1	0.38	0.12
Santa Rosa	80 ° 4 '20.96' 'W-0 ° 7' '29.41 " S	0.09	6.8	0.60	0.30
Hacienda el Rosario	80 ° 3 '5.11' 'W-0 ° 2' '58.72' 'S	0.29	11.2	3.25	0 .75
Quiauque Up'16.30	80 ° 2' 'W-0 ° 3" 'S	0.51	18.5	9.36	1.46
'11.10Cholote	80 ° 4' 18.51 " W- 0 ° 3 " 37.51 " S	0.23	4	0.93	0.33
Baloy	80 ° 5 '24.94' 'W-0 ° 10' '30.42' 'S	0.05	4	0, 18	0.06

Source: The Own elaboration based on data from: (De la Cruz & Zambrano, 2017)

The table shows the spatial information georeferenced with the data on the work carried out. This information is integrated into the studies carried out at the Technical University of Manabí (Rodríguez, Vázquez, Martínez & Bravo, 2019), on the hydraulic potential of the rivers in the province, with the aim of making it available with free access for local actors, teachers, researchers, students and all personnel interested in carrying out projects focused on the energy use of the province's hydraulic potential.

4. Conclusions

The investigation made it possible to verify that despite the fact that in all the communities studied and that are located in places near the Coaque River have electricity service, not in all cases the electricity is arriving with the required technical quality parameters, situation which becomes more conflictive during the winter months with the rains, where there are frequent interruptions of electricity service.

It was found that despite the fact that the Coaque River has little flow, in several places of the channel there are small potentials of hydraulic energy that can be used for the generation of electricity and thus be able to improve the quality of the electricity service, save natural resources and contribute with the reduction of COemissions$_2$ into the atmosphere.

The results of the work can facilitate the carrying out of studies and research focused on the use of the flow of the Coaque River for energy purposes.

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