Published in Energy Conversion & Management X with doi: 10.1016/j.ecmx.2022.100202

Design to include a wind turbine and socio-techno-economic analysis of an isolated airplane-type organic building based on a photovoltaic/hydrokinetic/battery

Daniel Icaza[1,2]*, Francisco Jurado[2] Marcos Tostado-Véliz[1] and Paúl Arevalo[1]

[1] Departament of Electrical Engineering
University of Jaen
Linares, SPAIN
[2] Departament of Electrical Engineering
Catholic University of Cuenca
Cuenca, ECUADOR

* Corresponding author. Tel: 593-985-154-839.
doia0001@red.ujaen.es (Daniel Icaza)

ABSTRACT

The global dynamics in the electricity sector generates development in the towns, this permanent search for new opportunities has made renewable energies visible as a very certain option and which is currently a reality to electrify areas that until recently were very difficult to reach. An isolated system where the potential for energy use exists leads to the formation of hybrid systems for the generation of clean energy and the possibilities of transformation of the sites that are defined can be of the highest value and valid to promote tourism in a sustainable way. In this research, a combination of these resources is presented for the supply of energy to an airplane-type building, the same one that serves to house people who want to get out of the stressful urban life level, it is an innovative and interesting study that is being launched in the Ecuador. Several researchers and developers consider this type of construction as organic constructions because of the spaces closely related to nature, very similar to the womb of the mother and her child within it. It is a fantastic study that allows configuring a hybrid system together with a support subsystem backed by a battery bank to guarantee the electrical supply of a set of isolated loads. The complete design of a hybrid system satisfies the energy requirements of a load. The methodology includes the optimal location of the wind turbine in a cross section close to the isolated airplane type construction to maximize the performance of the wind generator, additionally the techno-economic study of all the components of the hybrid system is considered for an efficient use of resources, considering the different seasons of the year. The results show that the hybrid system provides sufficient and timely power for the loads, the resources of the hydroelectric, wind and solar photovoltaic generation are optimized, maintaining the state of charge of the storage subsystem through the battery bank.

Keywords: Renewable energy, Clean energy, Techno-economic analysis, Energy transition, hydrokinetic, hybrid system.

Nomenclature

ACM	*Absorption cooling machine*
NCRE	*Non-conventional renewable energies.*
RE	*Renewable Energy*
COP	*Coefficient of performance*
EEC	*Economic European Community*
EU	*European Union*
IOT	*Internet of Things*
FPC	*Flat plate collectors*
HL	*Heating load*
YNP	*Yasuní National Park*
IEA	*International Energy Agency*
PE	*Primary energy*
PV	*Photovoltaic*

1. Introduction

Historically, fossil fuels have been used for energy supply in most countries of the world, their excessive consumption has caused high levels of pollution and global warming that is increasing [1]. Such is the level of concern that the international community was cited in 2015 at COP 21 in Paris [2], which brought together a large number of countries that had the purpose of preventing the increase in world temperature to 2 degrees Celsius during this century. COP 25 sought to take the necessary and successive steps to apply the rules of the Paris Agreement [3], with this actions and investments necessary for a sustainable future with low carbon emissions. According to [4] it is specified that new renewable energy capacity, mainly wind, hydroelectric, solar, geothermal and bioenergy, accounted for about 72% of all energy expansion in 2018. Renewable energy increased 7.6% in 2019, with a new added energy capacity of 176 gigawatts [5]. Despite this improved condition, there are still around 1.5 billion people in the world without access to electricity [6].

In recent years, renewable energy has played a preponderant role in the development of countries, above all it has a higher level of trust in society, in addition to the fact that prices are increasingly accessible to the different strata of society [7]. This high level of growth of renewable sources has increased energy production, especially in rural areas where it was difficult to reach with public distribution networks, mainly rural communities with topographically mountainous or rocky access and if the potential is available energetic [8]. Another possibility of electrification in these places has been over time by means of diesel or gasoline generators, but for a continuous supply of energy they require reserve fuel, in addition to being motorized and noisy, they are also polluting [9]. Fuel is excessively expensive considering all the management that must be carried out until reaching remote areas [10].

Historically, hydroelectricity has been the fundamental pillar for supplying electricity to different countries thanks to its wealthy rivers [11]. In South America all countries have a good percentage of energy from river reservoirs within their energy matrix [12]. The country with the highest contribution in hydroelectricity is Paraguay, with 100% according to the reference [13]. However, in recent years there are other technologies that are being part of the energy mix, especially wind and solar [14]. Various countries have considered these renewable energy sources as fundamental pillars for the supply of energy due to the shortage of oil and the negative consequences and its environmental impacts that it has caused in different countries [15]. Currently, wind energy has become globalized and especially in Europe it has made a very important contribution to the economic development of companies [16]. The technically exploited wind presents an excellent option for the development of the countries. Europe has policies associated with increasing the levels of use of wind energy and improving the level of productivity [17].

Examining the penetration levels of wind energy we see that the energy market is growing in South America and above all there are policies that encourage the use of renewable energy generation sources. Brazil is an example of taking advantage of this type of technology and the other countries are in that line [18], [19]. The use of wind energy in smaller countries such as Ecuador is also highlighted [20], with clear examples of moving towards decarbonisation, among the wind projects carried out are the Villonaco project [21], Baltra in Galapagos [22] and new wind projects such as the Minas de Huascachaca project [23].

Different researchers proposed hybrid systems and storage technologies for remote locations that depend on renewable sources available at the application site [24]–[26]. There are different investigations that are very focused on making better use of the available energy resources, they focus on system modeling, simulation and optimization criteria with the intention that energy is available continuously and of excellent quality [27]–[29].

H Ibrahim, and A. Ilinca, [30] showed 5 configurations among their experiments related to hybrid systems for the generation of electrical energy. The first configuration consisted of a wind turbine system and a battery bank for storage. The second configuration consisted of a wind-photovoltaic system backed by a battery bank. The third used a modern electrolyzer powered by excess energy from the photovoltaic system which produced hydrogen and was stored in a tank to finally feed a fuel cell for later reuse. The fourth configuration employed a low power wind turbine with a bank of batteries of storage. The fifth and final configuration combined a PV array, a low power wind turbine, and an FC. When all the optimization results were compared, they compared the energy production levels with the implementation costs and indicated that the best option among all the configurations studied was the photovoltaic system and fuel cell.

Zhiyu Huang et al. [31] studied different methods of hydrogen production under different environmental conditions with the presence of photovoltaic solar energy. and they came to the conclusion that the cost of hydrogen production with the use of photovoltaic solar energy is still high, even though the costs of its components in the last two years fell significantly. This system continues to face many problems of a technical nature, additionally, high costs of construction, maintenance and operation.

MH Jahangir et al. [32] conducted a study to determine the feasibility of a large-scale hybrid power system to operate off-grid or on-grid in cities near the sea. R Klyuev et al. [33] conducted a study for the implementation of wind power plants to supply permanent energy to high mountain territories. Both studies seek to make the most of the electrical power generated and have battery banks to back up the energy and allocate hours of non-generation.

D Song et al. [34] give general recommendations to make better use of the wind resource foreseen in each locality from the perspective of the variable speed of wind turbines. D. Icaza [28] implements and creates two models of low power wind turbines to exploit the wind potential in Ecuador [28], [35], especially in the Amazon and Galapagos [36]. The basis of these developments is in improving the positioning system of each wind turbine and maximizing the levels of energy production. Among the latest developments, AS Alexander et al. [37] designed an interesting mechanism for increasing power in two vertical axis wind turbines so that they are located next to each other.

Several researchers recognize an important advance in the design of new wind turbines and that they are very useful for the great decarbonization objectives in the countries [38], [39], they also recognize that it is important to give more impetus both to the individual development of these technologies but also to the combination in the The moment of installation will give greater utility and will have better results in applications that are carried out especially in rural areas without access to electricity.

M. Rezaei et al. [40] conducted a novel study, classifying different locations to better exploit wind energy production. However, Sunanda Sinha [41] considers in his study that it is important to improve the reliability of the electricity generation system based on photovoltaics with battery storage that even in places with little wind, it is necessary their combination and power the load.

Different researchers agree that hybrid systems are an adequate option to supply energy continuously to the load [42]–[44]. Jakub Jurasz simulated two hybrid systems with battery storage. The combinations were (PV/WT) [45], and (PV/WT/HKT) [46] and it is concluded that for the two options the system that presented the greatest innovation was the system where the HKT was a very profitable, reliable solution and totally respectful with the environment, in this way it constitutes an effective and autonomous option of 100% in autonomous applications, but it is also specified that achieving the three simultaneous systems is quite difficult for them to be present in the localities. Having the three wind, solar and hydraulic resources is a luxury combination for the localities.

Lee Wai Chong through [47] considers very important the use of batteries as a storage system for energy control, especially to be available in non-generation hours, this configuration has become widespread in different applications where hybrid systems intervene outside the conventional electrical network. On the other hand, UK Das [48] reviewed and compared current batteries with those of some time ago and states that it is important in a hybrid system to use batteries with good energy storage characteristics and all their components present adequate operating conditions.

Before putting the construction of these hybrid systems into reality, it is necessary to be highly certain that they are working properly and not put the investment at risk. Computer tools are currently used to model, simulate and study the behavior of these systems [49]. Among the most sophisticated and widely recommended simulation tools is HOMER (Hybrid Optimization Model for Electric Renewable Energies) [50]. This highly efficient software allows hybrid systems to be adequately analyzed, very attached to the implementation and according to the existing equipment in the market [51], additionally, optimization criteria can be introduced according to the system that we are designing and trying to put into operation [52]. Additionally, it is possible to have potential variants of the representative parameters of the system according to the geographical location [53].

The reference [54] in its literature addresses isolated systems and especially the use of the kinetic energy of water in open channels, where they do not necessarily have to be so large, but they can be very useful for various applications where electrical energy is required, usually known as hydrokinetics

(HKT). It is a clean energy production method, friendly to the environment and that is becoming fashion in Ecuador with the interest of providing sufficient and permanent energy in various places of the inter-Andean and Amazon mountain ranges [55]–[57]. Using this type of technology is not difficult, rather it requires having open channels to carry out the energy conversion process. Taking proper advantage of this type of technology, it could satisfy the demand of several isolated communities and carry out different applications that are aimed at developing the sectors, mainly they can be of enormous contribution to developing countries, for example in South America and Africa.

Brian Kirke [58] conducted a study analyzing the efficiency of hydrokinetic turbines for moderate-sized rivers, while M Anyi et al. [59] carried out a test of a hydrokinetic turbine that does not obstruct and can provide electricity continuously in rural locations. In this sense, AZ Anthony [60] in a recent study analyzed the performance of a Savonius type turbine in such a way that it modified its blades in order to make it more efficient in various rural applications.

Clear benefits of electricity supply have been developed in various parts of the world where moderate flow rivers are used, among them is the one developed in Sarawak using a turbine small-scale horizontal axis hydrokinetics as a good alternative for community electrification [61]. A study was carried out in the eastern channel of Yamuna where the hydrokinetic energy was evaluated [62].

In what corresponds to organic architectures, which is the type of building that is considered in this research and the purpose is to guarantee the electric power system through hybrid systems. Part of a philosophy that promotes harmony between the human habitat and the natural world. Through design, it seeks to understand the benefits of the territory and integrate the building in a harmonious way. In this sense, renewable energies are key pieces as a piece of a puzzle that takes advantage of resources such as water, wind, and the sun and can be technically channeled to supply autonomous energy to buildings. These buildings seek to welcome people who seek to enjoy the tranquility and comfort that these facilities provide with sufficient basic services, including electricity, which is the purpose of this research. One of the professionals who intensively addresses this type of construction is Javier Senosiain [63], his room and internal space designs are based on a model inspired by the womb of a mother with her child who is at rest and joy.

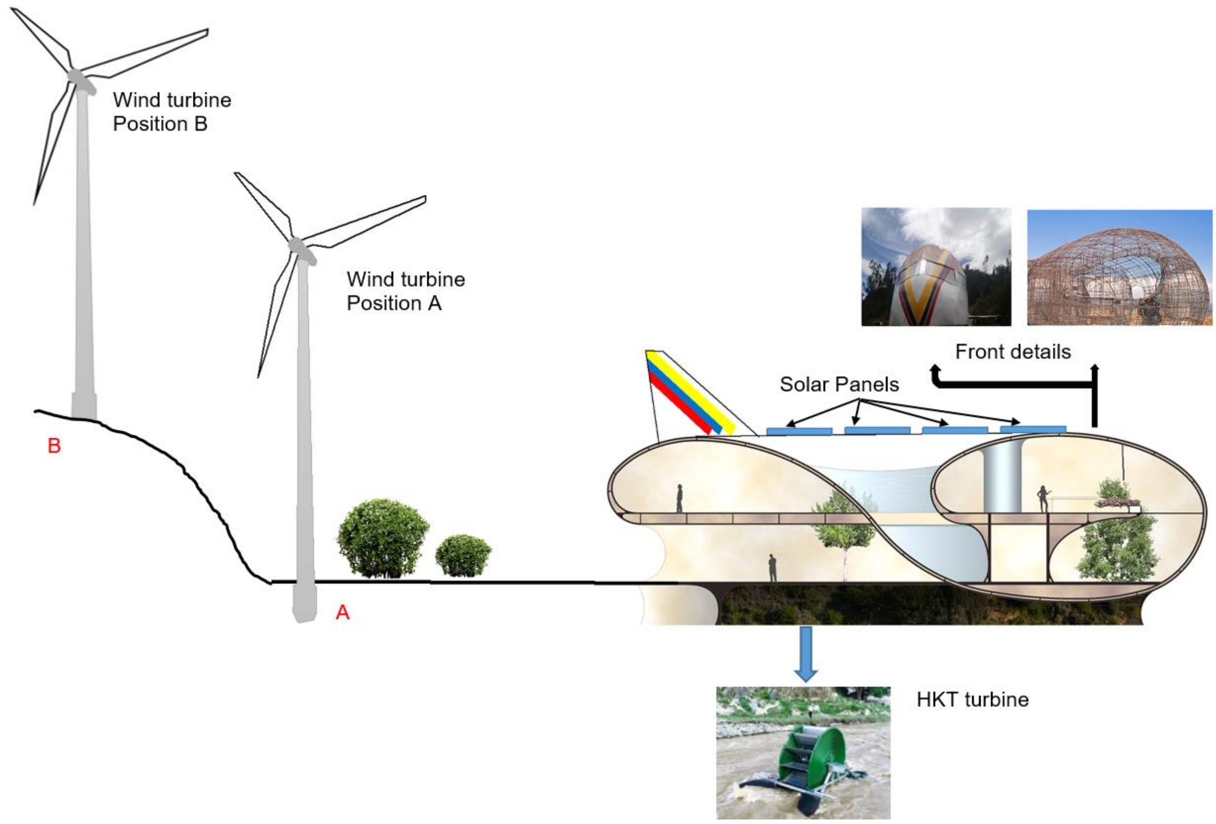
In this research, the optimal location of the wind turbine is specified to take better advantage of the wind resource in the conformation of the hybrid system in conjunction with the photovoltaic system and the kinetics of the open channel water. The study of hybrid systems in organic buildings has not been discussed, nor are there any technical and economic studies related to these buildings. In this type of research we are pioneers and we continue to carry out exhaustive studies after some important results in [64] and [65]. The main objective of this research is to supply electricity to the organic plane-type construction located in the rural area of El Valle-Cuenca, which has an area of 2.2Km^2 and has excellent characteristics to take advantage of solar, wind and energy resources. kinetic water, in this way to supply energy to the building. The place is located 9.3 km from the Heritage City of Cuenca. The organic construction is already carried out in its first phase and within the second one must supply energy, however it is important to consider the specific location of the wind turbine knowing that the solar panels will be located on the roof of the building and the HKT turbine You will be taking advantage of the open channel of the Maluay River. The study involves a tripartite methodology. In the first part carry out simulations and evaluation of the wind potential in the area at mountain level (take advantage of the hill wind) and near the building (take advantage of the wind tunnel) to later determine the results in the two positions. In this part we also consider the variability of the load according to the seasonal profile that is discussed in section 2. Once the tabulated data related to wind speed are available, the ideal location of the wind turbine and the simulated results are validated with actual measured data. In the second stage, the hybrid system is dimensioned for the electrical supply of the organic architecture located on the site. The hybrid system, in addition to the wind system, is made up of photovoltaic and HKT solar panels, and also has a battery bank as a backup and storage for night hours.
In the third stage, the socio-technical-economic evaluation of the designed hybrid system is carried out. In this part, the general results obtained are evaluated and the current cost of the implementation of the electricity production system (NPC) is determined.

This article presents a novel study of an isolated organic construction powered by a hybrid system composed of PV WT / HKT / BT, its performance is determined according to the optimal location of the wind turbine.

Below is shown in figure 1a the organic construction supported by google earth in the geographic coordinates 2°56’24”S,78°56'16”W, in figure 1b the complete construction of the airplane type organic construction is shown. While in figure 1c the location of the main equipment that makes up the sources of supply for organic construction is specified. The position of the wind turbine is part of the purpose of determining its location either at hill level or in the valley near the building. This studio is located in a strategic place where calm reigns, it has an enviable nature, ready to receive human beings for their exclusive enjoyment and comfort.

(a)

(b)



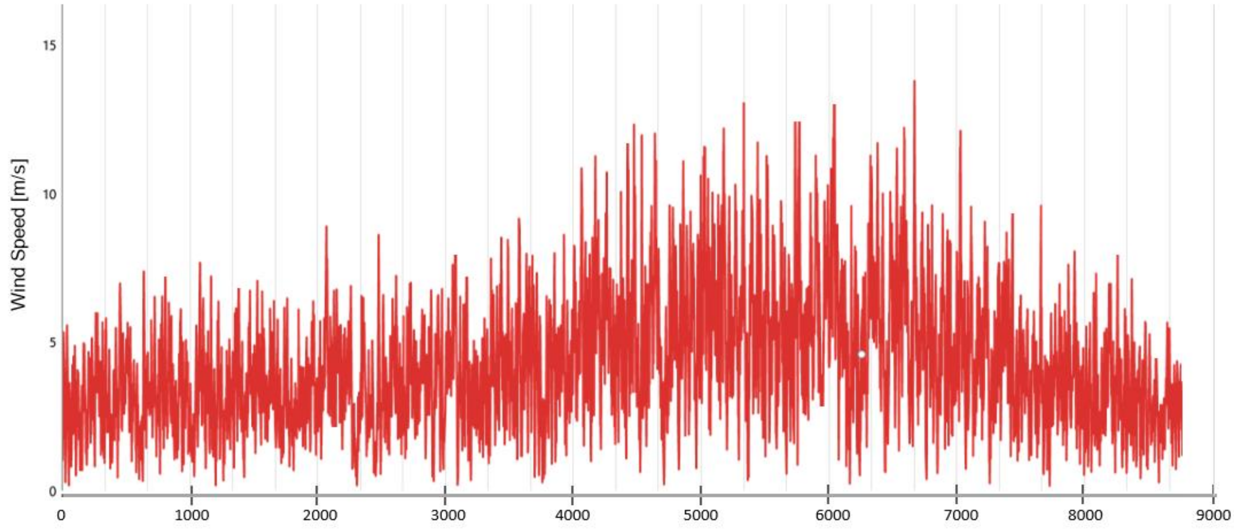
(c)

Fig. 1. (a) Organic airplane type construction seen from google earth. (b) Organic construction supplied by 100% renewable energy. (c) General scheme of power supply to the organic construction type airplane.

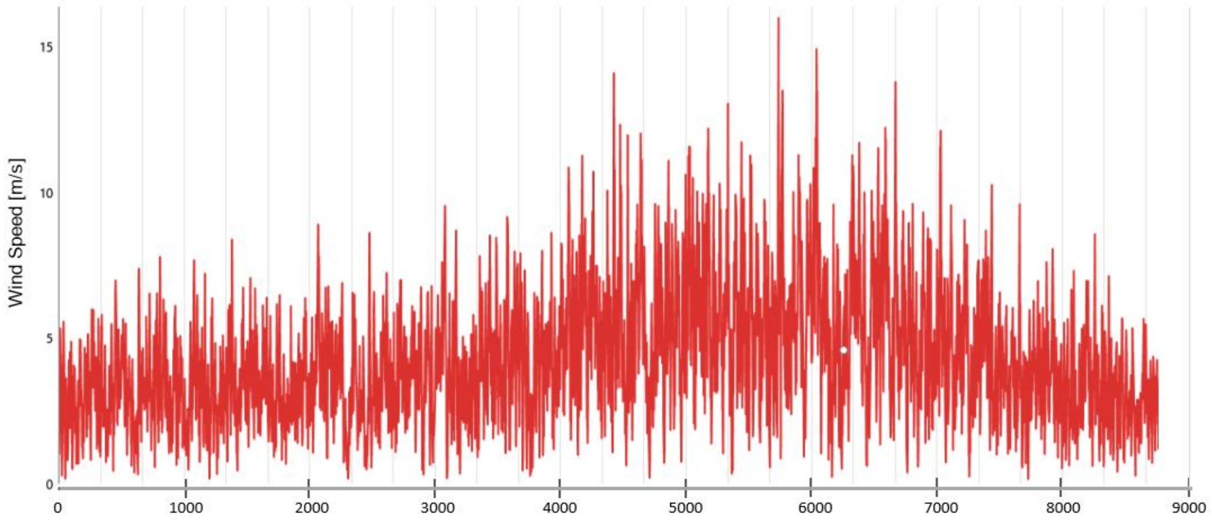
2. Evaluation of the energy potential in the locality and optimal location of the wind turbine

The interest aroused by this study is really important, in the area two meteorological stations were installed during 2020, with special emphasis on determining the wind potential at hill level and at valley level. In the first instance, it was sought to take advantage of available software to evaluate the wind potential, however their differences were not accurately identified, so the decision was made to measure the wind speeds in the two sites. The hill belongs to the property where the airplane-type organic construction is located, it has a very important elevation, it is not far away and there is a prominent wind that, without being the highest, can be of great contribution to supply the organic construction, without However, at the valley level, at the same level as the organic construction, it is possible to take advantage of the wind tunnels that come from the heights of the nascent Maluay River. For this reason, we proceeded to evaluate the wind potential in the two positions and decide on the most feasible that even in the future a phase II would be developed with the increase in the greater number of organic constructions. The vegetation in certain points is exuberant and it is interesting to keep it intact, except for the usual pruning that is carried out periodically but which does not result in obstacles to take advantage of the wind in a better way. By contrasting curves 2a and 2b, it can be seen that position B at hill level gives us better options for the exploitation of this wind source since the speeds that occur are higher, additionally the voltage drop per distance will not exceed 2% so it is a very good option to permanently install the wind generator on the hill. The terrain at that level is firm there are no possibilities of landslides or dangers of rock falls.

It is important to note that, apart from having a slightly higher speed profile on the hill, the turbine is also better appreciated in height since it should not be lost sight of the fact that all its surroundings must be harmoniously contrasted. Wind turbines are currently designed with high quality standards, however it is no less true that there will be small dips at night when the machine is operating, this is also a reason why it is defined that the wind turbine is on the hill and do not interfere with the harmonic rest of people inside the organic construction.



(a)



(b)

Fig. 2. (a) Annual speed profile at point A taking advantage of the wind tunnel. (b) Annual speed profile at point B taking advantage of the hill wind.

Generated mechanical power output from the wind turbine can be written using equation (1) which is depending on wind speed (V_{WT})=v, R is the turbine radius, $\rho_a$air density and C_p is Performance coefficient.

$$P_{WT}(t) = \frac{1}{2} C_p(\lambda,\ \beta)\rho_a A v^3 \qquad (1)$$

The output power of the wind turbine is a function of the wind speed and is considered according to the limits expressed by (2), according to reference [66]:

$$P_{pv}^{av}(t) = \begin{cases} 0\ if\ v < V_I \\ \frac{1}{2} C_p(\lambda, \beta) \\ P_w^r\ if\ v_r < v < v_c \\ 0\ if\ v > v_c \end{cases} \rho_a A v^3(t)\ if\ V_i \le v \le v_r \qquad (2)$$

3. Hybrid system model

The hybrid system used in this research consists of a HKT, PV, WT that includes an energy backup system (storage) using lead acid batteries, mainly for night hours or for lack of sufficient power generation by the hybrid system. Fig. 3 shows the hybrid system used by the HOMER PRO software.

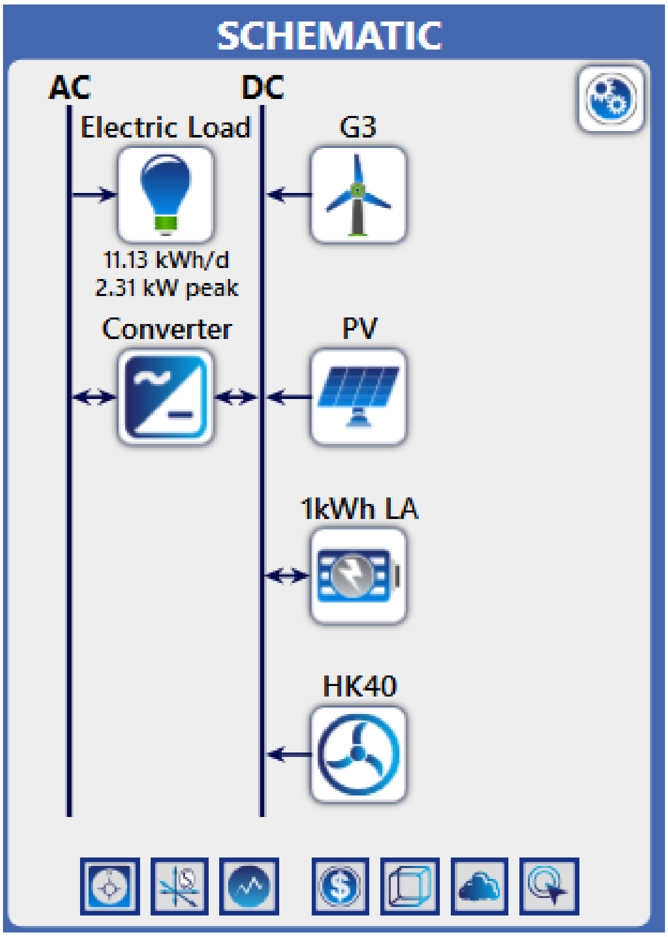
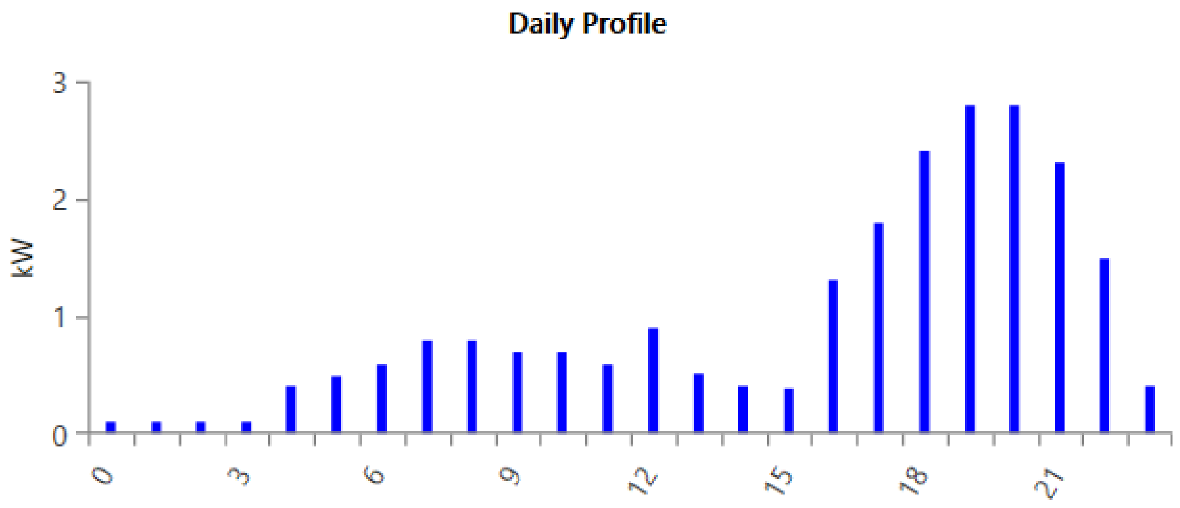


Fig. 3. Hybrid system designed using HOMER PRO software.

3.1. Main constituent elements of the hybrid system.

3.1.1. Wind turbine.



Expressions of gratitude.

The authors wish to acknowledge the Illustrious Municipality of Cuenca and CELEC EP that provided all the framework to carry out these calculations and analyses, as well as the Ecuadorian State Institutions such as ARCONEL, CONELEC and HIDROPAUTE that through their public officials provided specific information so that this investigation comes to fruition.

References

[1] J. Eom, M. Hyun, J. Lee, y H. Lee, «Increase in household energy consumption due to ambient air pollution», *Nat. Energy*, vol. 5, n.º 12, pp. 976-984, dic. 2020, doi: 10.1038/s41560-020-00698-1.

[2] J. A. Berruezo y J. D. Jiménez, «Situación del Convenio Marco de Naciones Unidas sobre el Cambio Climático. Resumen de las Cumbres de París, COP21 y de Marrakech, COP22», *Rev. Salud Ambient.*, vol. 17, n.º 1, pp. 34-39, jun. 2017, Accedido: ago. 29, 2020. [En línea]. Disponible en: http://www.ojs.diffundit.com/index.php/rsa/article/view/839.

[3] M. Asadnabizadeh, «Development of UN Framework Convention on Climate Change Negotiations under COP25: Article 6 of the Paris Agreement perspective», *Open Polit. Sci.*, vol. 2, n.º 1, pp. 113-119, dic. 2019, doi: 10.1515/openps-2019-0012.

[4] S. R. Sinsel, R. L. Riemke, y V. H. Hoffmann, «Challenges and solution technologies for the integration of variable renewable energy sources—a review», *Renew. Energy*, vol. 145, pp. 2271-2285, ene. 2020, doi: 10.1016/j.renene.2019.06.147.

[5] H. Zhao y W. Lifeng, «Forecasting the non-renewable energy consumption by an adjacent accumulation grey model», *J. Clean. Prod.*, vol. 275, p. 124113, dic. 2020, doi: 10.1016/j.jclepro.2020.124113.

[6] J. Ayaburi, M. Bazilian, J. Kincer, y T. Moss, «Measuring "Reasonably Reliable" access to electricity services», *Electr. J.*, vol. 33, n.º 7, p. 106828, ago. 2020, doi: 10.1016/j.tej.2020.106828.

[7] D. Fouquet, «Policy instruments for renewable energy – From a European perspective», *Renew. Energy*, vol. 49, pp. 15-18, ene. 2013, doi: 10.1016/j.renene.2012.01.075.

[8] A. Razmjoo, L. Gakenia Kaigutha, M. A. Vaziri Rad, M. Marzband, A. Davarpanah, y M. Denai, «A Technical analysis investigating energy sustainability utilizing reliable renewable energy sources to reduce CO2 emissions in a high potential area», *Renew. Energy*, vol. 164, pp. 46-57, feb. 2021, doi: 10.1016/j.renene.2020.09.042.

[9] U. Gehring, L. Tamburic, H. Sbihi, H. W. Davies, y M. Brauer, «Impact of Noise and Air Pollution on Pregnancy Outcomes», *Epidemiology*, vol. 25, n.º 3, pp. 351-358, 2014, Accedido: dic. 10, 2020. [En línea]. Disponible en: https://www.jstor.org/stable/24759126.

[10] P. Marocco *et al.*, «A study of the techno-economic feasibility of H2-based energy storage systems in remote areas», *Energy Convers. Manag.*, vol. 211, p. 112768, may 2020, doi: 10.1016/j.enconman.2020.112768.

[11] J. Xu, T. Ni, y B. Zheng, «Hydropower development trends from a technological paradigm perspective», *Energy Convers. Manag.*, vol. 90, pp. 195-206, ene. 2015, doi: 10.1016/j.enconman.2014.11.016.

[12] J. M. Kissel, R. Hanitsch, y S. C. W. Krauter, «Cornerstones of a renewable energy law for emerging markets in South America», *Energy Policy*, vol. 37, n.º 9, pp. 3621-3626, sep. 2009, doi: 10.1016/j.enpol.2009.04.018.

[13] L. de S. N. S. Barbosa, D. Bogdanov, P. Vainikka, y C. Breyer, «Hydro, wind and solar power as a base for a 100% renewable energy supply for South and Central America», *PLOS ONE*, vol. 12, n.º 3, p. e0173820, mar. 2017, doi: 10.1371/journal.pone.0173820.

[14] «World Energy Outlook 2019 – Analysis», *IEA*. https://www.iea.org/reports/world-energy-outlook-2019 (accedido ago. 27, 2020).

[15] «Detection of oil pollution impacts on vegetation using multifrequency SAR, multispectral images with fuzzy forest and random forest methods», *Environ. Pollut.*, vol. 256, p. 113360, ene. 2020, doi: 10.1016/j.envpol.2019.113360.

[16] T. Ackermann y L. Söder, «Wind energy technology and current status: a review», *Renew. Sustain. Energy Rev.*, vol. 4, n.º 4, pp. 315-374, dic. 2000, doi: 10.1016/S1364-0321(00)00004-6.

[17] R. McKenna *et al.*, «On the socio-technical potential for onshore wind in Europe: A response to Enevoldsen et al. (2019), Energy Policy, 132, 1092-1100», *Energy Policy*, vol. 145, p. 111693, oct. 2020, doi: 10.1016/j.enpol.2020.111693.

[18] P. de Jong *et al.*, «Estimating the impact of climate change on wind and solar energy in Brazil using a South American regional climate model», *Renew. Energy*, vol. 141, pp. 390-401, oct. 2019, doi: 10.1016/j.renene.2019.03.086.

[19] W. C. Nadaleti, G. B. dos Santos, y V. A. Lourenço, «Integration of renewable energies using the surplus capacity of wind farms to generate H2 and electricity in Brazil and in the Rio Grande do Sul state: energy planning and avoided emissions within a circular economy», *Int. J. Hydrog. Energy*, vol. 45, n.º 46, pp. 24190-24202, sep. 2020, doi: 10.1016/j.ijhydene.2020.06.226.

[20] M. A. Ponce-Jara, M. Castro, M. R. Pelaez-Samaniego, J. L. Espinoza-Abad, y E. Ruiz, «Electricity sector in Ecuador: An overview of the 2007–2017 decade», *Energy Policy*, vol. 113, pp. 513-522, feb. 2018, doi: 10.1016/j.enpol.2017.11.036.

[21] D. Icaza, C. Salinas, D. Moncayo, F. Icaza, A. Cárdenas, y Ma. A. Tello, «Production of Energy in the Villonaco Wind Farm in Ecuador», en *2018 World Engineering Education Forum - Global Engineering Deans Council (WEEF-GEDC)*, nov. 2018, pp. 1-7, doi: 10.1109/WEEF-GEDC.2018.8629596.

[22] A. F. Porras-Ortiz, J. Layedra, y H. Arcos, «Active power loss minimization in the Santa Cruz and Baltra hybrid energy system using particle swarm optimization», en *2015 IEEE PES Innovative Smart Grid Technologies Latin America (ISGT LATAM)*, oct. 2015, pp. 429-434, doi: 10.1109/ISGT-LA.2015.7381193.

[23] D. Icaza, F. Jurado, S. P. Galindo, F. Córdova, y J. Portoviejo, «Minas of Huascachaca wind project in Ecuador», en *2020 9th International Conference on Renewable Energy Research and Application (ICRERA)*, sep. 2020, pp. 515-519, doi: 10.1109/ICRERA49962.2020.9242895.

[24] A. Ghaffari y A. Askarzadeh, «Design optimization of a hybrid system subject to reliability level and renewable energy penetration», *Energy*, vol. 193, p. 116754, feb. 2020, doi: 10.1016/j.energy.2019.116754.

[25] H. Mehrjerdi, «Modeling, integration, and optimal selection of the turbine technology in the hybrid wind-photovoltaic renewable energy system design», *Energy Convers. Manag.*, vol. 205, p. 112350, feb. 2020, doi: 10.1016/j.enconman.2019.112350.

[26] C. Mokhtara, B. Negrou, A. Bouferrouk, Y. Yao, N. Settou, y M. Ramadan, «Integrated supply–demand energy management for optimal design of off-grid hybrid renewable energy systems for residential electrification in arid climates», *Energy Convers. Manag.*, vol. 221, p. 113192, oct. 2020, doi: 10.1016/j.enconman.2020.113192.

[27] H. Mehrjerdi, «Modeling and optimization of an island water-energy nexus powered by a hybrid solar-wind renewable system», *Energy*, vol. 197, p. 117217, abr. 2020, doi: 10.1016/j.energy.2020.117217.

[28] D. I. Alvarez, «Modeling, simulation and construction of the D-ICAZA-A1 wind turbine destined for the rural areas of ecuador», en *2017 IEEE PES Innovative Smart Grid Technologies Conference - Latin America (ISGT Latin America)*, Quito, sep. 2017, pp. 1-6, doi: 10.1109/ISGT-LA.2017.8126742.

[29] D. Icaza, S. Pulla, y F. Icaza, «Modeling, Simulation and Construction of a Wind Turbine with Chain Multiplication System9 Destined to Rural Areas of the Canton Cuenca-Ecuador», en *2018 7th International Conference on Renewable Energy Research and Applications (ICRERA)*, oct. 2018, pp. 1240-1246, doi: 10.1109/ICRERA.2018.8566739.

[30] H. Ibrahim y A. Ilinca, «Techno-Economic Analysis of Different Energy Storage Technologies», *Energy Storage - Technol. Appl.*, ene. 2013, doi: 10.5772/52220.
[31] Z. Huang *et al.*, «Modeling and multi-objective optimization of a stand-alone PV-hydrogen-retired EV battery hybrid energy system», *Energy Convers. Manag.*, vol. 181, pp. 80-92, feb. 2019, doi: 10.1016/j.enconman.2018.11.079.
[32] M. H. Jahangir, S. Fakouriyan, M. A. Vaziri Rad, y H. Dehghan, «Feasibility study of on/off grid large-scale PV/WT/WEC hybrid energy system in coastal cities: A case-based research», *Renew. Energy*, vol. 162, pp. 2075-2095, dic. 2020, doi: 10.1016/j.renene.2020.09.131.
[33] R. Klyuev, I. Bosikov, y O. Gavrina, «Use of Wind Power Stations for Energy Supply to Consumers in Mountain Territories», en *2019 International Ural Conference on Electrical Power Engineering (UralCon)*, oct. 2019, pp. 116-121, doi: 10.1109/URALCON.2019.8877674.
[34] D. Song *et al.*, «New perspectives on maximum wind energy extraction of variable-speed wind turbines using previewed wind speeds», *Energy Convers. Manag.*, vol. 206, p. 112496, feb. 2020, doi: 10.1016/j.enconman.2020.112496.
[35] D. Icaza, H. Conce, P. Flores, y F. Conce, «Dimensioning of the main mechanical elements and final assembly of the DIAWIND-A2 wind turbine», en *2017 CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON)*, oct. 2017, pp. 1-6, doi: 10.1109/CHILECON.2017.8229551.
[36] D. Icaza, S. Pulla, I. Colak, C. Flores, y F. Córdova, «Modeling, Simulation and Stability Analysis of a Low-Wind Turbine for the Supply of Energy to the Amazon Jungle and Galapagos in Ecuador», en *2018 7th International Conference on Renewable Energy Research and Applications (ICRERA)*, oct. 2018, pp. 100-105, doi: 10.1109/ICRERA.2018.8566858.
[37] A. S. Alexander y A. Santhanakrishnan, «Mechanisms of power augmentation in two side-by-side vertical axis wind turbines», *Renew. Energy*, vol. 148, pp. 600-610, abr. 2020, doi: 10.1016/j.renene.2019.10.149.
[38] T. Canale, K. A. R. Ismail, F. A. M. Lino, y A. Arabkoohsar, «Comparative Study of New Airfoils for Small Horizontal Axis Wind Turbines», *J. Sol. Energy Eng.*, vol. 142, n.º 041004, feb. 2020, doi: 10.1115/1.4046089.
[39] G. A. Gohar *et al.*, «Design and comparative analysis of an INVELOX wind power generation system for multiple wind turbines through computational fluid dynamics», *Adv. Mech. Eng.*, vol. 11, n.º 4, p. 1687814019831475, abr. 2019, doi: 10.1177/1687814019831475.
[40] M. Rezaei, A. Mostafaeipour, M. Qolipour, y R. Tavakkoli-Moghaddam, «Investigation of the optimal location design of a hybrid wind-solar plant: A case study», *Int. J. Hydrog. Energy*, vol. 43, n.º 1, pp. 100-114, ene. 2018, doi: 10.1016/j.ijhydene.2017.10.147.
[41] S. Sinha y S. S. Chandel, «Improving the reliability of photovoltaic-based hybrid power system with battery storage in low wind locations», *Sustain. Energy Technol. Assess.*, vol. 19, pp. 146-159, feb. 2017, doi: 10.1016/j.seta.2017.01.008.
[42] J. Kartite y M. Cherkaoui, «Study of the different structures of hybrid systems in renewable energies: A review», *Energy Procedia*, vol. 157, pp. 323-330, ene. 2019, doi: 10.1016/j.egypro.2018.11.197.
[43] E. O. Diemuodeke, A. Addo, C. O. C. Oko, Y. Mulugetta, y M. M. Ojapah, «Optimal mapping of hybrid renewable energy systems for locations using multi-criteria decision-making algorithm», *Renew. Energy*, vol. 134, pp. 461-477, abr. 2019, doi: 10.1016/j.renene.2018.11.055.
[44] S. Sinha y S. S. Chandel, «Review of recent trends in optimization techniques for solar photovoltaic–wind based hybrid energy systems», *Renew. Sustain. Energy Rev.*, vol. 50, pp. 755-769, oct. 2015, doi: 10.1016/j.rser.2015.05.040.

[45] J. Jurasz, A. Beluco, y F. A. Canales, «The impact of complementarity on power supply reliability of small scale hybrid energy systems», *Energy*, vol. 161, pp. 737-743, oct. 2018, doi: 10.1016/j.energy.2018.07.182.
[46] J. Jurasz, A. Piasecki, y M. Wdowikowski, «Assessing temporal complementarity of solar, wind and hydrokinetic energy», *E3S Web Conf.*, vol. 10, p. 00032, 2016, doi: 10.1051/e3sconf/20161000032.
[47] L. W. Chong, Y. W. Wong, R. K. Rajkumar, R. K. Rajkumar, y D. Isa, «Hybrid energy storage systems and control strategies for stand-alone renewable energy power systems», *Renew. Sustain. Energy Rev.*, vol. 66, pp. 174-189, dic. 2016, doi: 10.1016/j.rser.2016.07.059.
[48] U. K. Das *et al.*, «Advancement of lithium-ion battery cells voltage equalization techniques: A review», *Renew. Sustain. Energy Rev.*, vol. 134, p. 110227, dic. 2020, doi: 10.1016/j.rser.2020.110227.
[49] M. S. Branicky, «Universal computation and other capabilities of hybrid and continuous dynamical systems», *Theor. Comput. Sci.*, vol. 138, n.º 1, pp. 67-100, feb. 1995, doi: 10.1016/0304-3975(94)00147-B.
[50] P. Lilienthal, L. Flowers, y C. Rossmann, «HOMER: The hybrid optimization model for electric renewable», American Wind Energy Association, Washington, DC (United States), CONF-950309-, dic. 1995. Accedido: dic. 23, 2020. [En línea]. Disponible en: https://www.osti.gov/biblio/269387.
[51] «Systems and methods of reducing financing costs for renewable energy consumer premises equipment», ene. 12, 2007.
[52] T. Tezer, R. Yaman, y G. Yaman, «Evaluation of approaches used for optimization of stand-alone hybrid renewable energy systems», *Renew. Sustain. Energy Rev.*, vol. 73, pp. 840-853, jun. 2017, doi: 10.1016/j.rser.2017.01.118.
[53] S. Sinha y S. S. Chandel, «Review of software tools for hybrid renewable energy systems», *Renew. Sustain. Energy Rev.*, vol. 32, pp. 192-205, abr. 2014, doi: 10.1016/j.rser.2014.01.035.
[54] A. Ramadan, M. A. A. Nawar, y M. H. Mohamed, «Performance evaluation of a drag hydro kinetic turbine for rivers current energy extraction - A case study», *Ocean Eng.*, vol. 195, p. 106699, ene. 2020, doi: 10.1016/j.oceaneng.2019.106699.
[55] B. Guáitara, J. Buele, F. W. Salazar, y J. Varela-Aldás, «Prototype of a Low Cost Turbine for the Generation of Clean Energy in the Ecuadorian Amazon», en *Information and Communication Technologies*, Cham, 2020, pp. 564-571, doi: 10.1007/978-3-030-62833-8_41.
[56] M. Botto-Tobar, M. Z. Vizuete, P. Torres-Carrión, S. M. León, G. P. Vásquez, y B. Durakovic, *Applied Technologies: First International Conference, ICAT 2019, Quito, Ecuador, December 3–5, 2019, Proceedings, Part I*. Springer Nature, 2020.
[57] R. V. Agila, D. Icaza, y J. González, «Optimization of the use and Exploitation of the Water Resource of the Catchments of the "Hydroelectric Power Plant Ing. Carlos Mora Carrion" located in the Canton of Zamora», en *2020 9th International Conference on Renewable Energy Research and Application (ICRERA)*, sep. 2020, pp. 526-531, doi: 10.1109/ICRERA49962.2020.9242881.
[58] «Hydrokinetic turbines for moderate sized rivers», *Energy Sustain. Dev.*, vol. 58, pp. 182-195, oct. 2020, doi: 10.1016/j.esd.2020.08.003.
[59] M. Anyi y B. Kirke, «Tests on a non-clogging hydrokinetic turbine», *Energy Sustain. Dev.*, vol. 25, pp. 50-55, abr. 2015, doi: 10.1016/j.esd.2015.01.001.
[60] A. Z. Anthony y S. Roy, «Performance analysis of a modified Savonius hydrokinetic turbine blade for rural application», *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 943, p. 012034, nov. 2020, doi: 10.1088/1757-899X/943/1/012034.
[61] T. K. Wee, M. Anyi, y N. S. Song, «Small-Scale Horizontal Axis Hydrokinetic Turbine as Alternative for Remote Community Electrification in Sarawak», en *2020*

International Conference on Smart Grid and Clean Energy Technologies (ICSGCE), oct. 2020, pp. 131-136, doi: 10.1109/ICSGCE49177.2020.9275631.

[62] G. Saini, A. Kumar, y R. P. Saini, «Assessment of hydrokinetic energy – A case study of eastern Yamuna canal», *Mater. Today Proc.*, sep. 2020, doi: 10.1016/j.matpr.2020.08.595.

[63] «LIBUN», *Senosiain, J. Arquitectura Organica, Memoria de la Exposición en el Museo Nacional de Arquitectura; Presentado en la Ciudad de México, Paseo de los Tamarindos 400B, suite 109 Col. Bosques de las Lomas, C.P. 05120; Impreso en China; AM Editores: Mexico, 2017; pp. 1–176. ISBN 978-607-437-414-8.* https://www.libun.edu.pe/carrito/principal.php/articulo/00152467 (accedido dic. 23, 2020).

[64] D. Icaza, P. Chacho, D. Ramirez, J. Peñaloza, H. Mejía, y S. Romero, «Telecommunication System for the Monitoring of Tourist Hotels Type Airplane and Heritage Monuments Supplied by Solar Energy.», en *2019 IEEE CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON)*, nov. 2019, pp. 1-8, doi: 10.1109/CHILECON47746.2019.8987456.

[65] D. Icaza, D. Borge-Diez, S. Pulla Galindo, y C. Flores-Vázquez, «Modeling and Simulation of a Hybrid System of Solar Panels and Wind Turbines for the Supply of Autonomous Electrical Energy to Organic Architectures», *Energies*, vol. 13, n.º 18, p. 4649, ene. 2020, doi: 10.3390/en13184649.

[66] M. Ourahou, W. Ayrir, B. EL Hassouni, y A. Haddi, «Review on smart grid control and reliability in presence of renewable energies: Challenges and prospects», *Math. Comput. Simul.*, vol. 167, pp. 19-31, ene. 2020, doi: 10.1016/j.matcom.2018.11.009.

[1] Chauhan A, Saini RP. A review on Integrated Renewable Energy System based power generation for stand-alone applications: Configurations, storage options, sizing methodologies and control. Renewable and Sustainable Energy Reviews. 2014 Oct 1;38:99-120.

[2] Agencia Internacional de Energía. World Energy Outlook 2019. IEA, Paris. Publicaciones; 2019.

[3] Kanninen M. Silvopastoral systems and carbon storage: Potential for Latin America. Potentialities of Silvopastoral Systems for the Generation of Environmental Services; 2003, 54.

[4] Rogel E, Pineda I, Jarrin M. Política económica de la UE en la disminución del consumo de hidrocarburos desde el 2020. *Revista Universidad y Sociedad* 11.2; 2019: 15-30.

[5] Economides M J. We are facing an imminent global oil shortage?. *Vanguardia dossier*, 2006, no 18, p. 6-14.

[6] Fernandez-Reyes R. The Paris Agreement and transformational change. Roles of Ecosocial Relations and Global Change*, 132, 101-114.*, 2016.

[7] Berruezo J, Jiménez J. Status of the United Nations Framework Convention on climate change. Summary of the Summits of Paris, COP21 and Marrakech, COP22. Environmental Health Magazine, 2017, vol. 17, no 1, p. 34-39.

[8] Campins M. COP25: entre la frustración y la resignación. *The Conversation, 2019*, 2019.

[9] Medina VD, Rosales JO, Martínez A P. Necesario periodo de reflexión constitucional y climática entre la Cop 25 y la COP 26. *Revista de Derecho Ambiental*, 2019, no 12, p. 1-5.

[10] Chauhan A, Saini R. A review on Integrated Renewable Energy System based power generation for stand-alone applications: Configurations, storage options, sizing methodologies and control. *Renewable and Sustainable Energy Reviews*, 2014, vol. 38, p. 99-120.

[11] Dominković DF, Bačeković I, Ćosić B, Krajačić G. Zero carbon energy system of South East Europe in 2050. *Applied energy* 184 (2016): 1517-1528.

[12] EnergyPLAN n.d. http://www.energyplan.eu/smartenergysystems/ [accesed May 2020 1,2020].

[13] Bogdanov D, Breyer C. North-East Asian Super Grid for 100% renewable energy supply: Optimal mix of energy technologies for electricity, gas and heat supply options. *Energy Conversion and Management* 112 (2016): 176-190.

[14] Child M, Nordling A. Breyer C. Scenarios for a sustainable energy system in the Åland Islands in 2030. *Energy conversion and management*, 2017, vol. 137, p. 49-60.

[15] Connolly D. Lund H, Mathiesen BV. Smart Energy Europe: The technical and economic impact of one potential 100% renewable energy scenario for the European Union. *Renewable and Sustainable Energy Reviews*, 2016, vol. 60, p. 1634-1653.

[16] Fell HJ. *Global cooling: Strategies for climate protection*. CRC Press, 2012.

[17] Unger N. Human land-use-driven reduction of forest volatiles cools global climate. *Nature Climate Change*, 2014, vol. 4, no 10, p. 907.

[18] Jebli MB, Youssef SB. Output, renewable and non-renewable energy consumption and international trade: Evidence from a panel of 69 countries. *Renewable energy*, 2015, vol. 83, p. 799-808.

[19] Sartzetakis ES. Green bonds as an instrument to finance low carbon transition. *Economic Change and Restructuring*, 2020, p. 1-25.

[20] Lund H, Mathiesen BV. Energy system analysis of 100% renewable energy systems—The case of Denmark in years 2030 and 2050. *Energy*, 2009, vol. 34, no5, p. 524 - 531.

[21] Hansen K, Mathiesen BV, Skov I R. Full energy system transition towards 100% renewable energy in Germany in 2050. *Renewable and Sustainable Energy Reviews*, 2019, vol. 102, p. 1-13.

[22] Child M, Kemfert C, Bogdanov D, Breyer C. Flexible electricity generation, grid exchange and storage for the transition to a 100% renewable energy system in Europe. *Renewable energy*, 2019, vol. 139, p. 80-101.

[23] Lo K. A critical review of China's rapidly developing renewable energy and energy efficiency policies. *Renewable and Sustainable Energy Reviews*, 2014, vol. 29, p. 508-516.

[24] Ma M, Cai W, Wu Y. China act on the energy efficiency of civil buildings (2008): a decade review. *Science of The Total Environment*, 2019, vol. 651, p. 42-60.

[25] Curran L, Lv P, Spigarelli F. Chinese investment in the EU renewable energy sector: Motives, synergies and policy implications. *Energy Policy*, 2017, vol. 101, p. 670-682.

[26] De Alegría Mancisidor IM, De Basurto Uraga PD. European Union's renewable energy sources and energy efficiency policy review: The Spanish perspective. *Renewable and Sustainable Energy Reviews*, 2009, vol. 13, no 1, p. 100-114.

[27] Jami AAN, Walsh PR. The role of public participation in identifying stakeholder synergies in wind power project development: The case study of Ontario, Canada. *Renewable energy*, 2014, vol. 68, p. 194-202.

[28] Van Beers D, Biswas WK. A regional synergy approach to energy recovery: The case of the Kwinana industrial area, Western Australia. *Energy conversion and management*, 2008, vol. 49, no 11, p. 3051-3062.

[29] Bossmann T, Eser EJ. Model-based assessment of demand-response measures—A comprehensive literature review. *Renewable and Sustainable Energy Reviews*, 2016, vol. 57, p. 1637-1656.

[30] Shariatzadeh F, Mandal P, Srivastava AK. Demand response for sustainable energy systems: A review, application and implementation strategy. *Renewable and Sustainable Energy Reviews*, 2015, vol. 45, p. 343-350.

[31] Kakran S, Chanana S. Smart operations of smart grids integrated with distributed generation: A review. *Renewable and Sustainable Energy Reviews*, 2018, vol. 81, p. 524-535.

[32] Lewis J, Severnini E. Short-and long-run impacts of rural electrification: evidence from the historical rollout of the us power grid. *Journal of Development Economics*, 2020, vol. 143, p. 102412.

[33] Hossain FM, Hasanuzzaman M, Rahim NA. Impact of renewable energy on rural electrification in Malaysia: a review. *Clean Technologies and Environmental Policy*, 2015, vol. 17, no 4, p. 859-871.

[34] Elbatran, AH, Yaakov OB, Ahmed YM. Operation, performance and economic analysis of low head micro-hydropower turbines for rural and remote areas: A review. *Renewable and Sustainable Energy Reviews*, 2015, vol. 43, p. 40-50.

[35] Shaahid SM, El-Amin I. Techno-economic evaluation of off-grid hybrid photovoltaic–diesel–battery power systems for rural electrification in Saudi Arabia—a way forward for sustainable development. *Renewable and Sustainable Energy Reviews*, 2009, vol. 13, no 3, p. 625-633.

[36] Javadi FS, Rismanchi B, Sarraf O Afshar. Global policy of rural electrification. *Renewable and Sustainable Energy Reviews*, 2013, vol. 19, p. 402-416.

[37] Boute A. Off-grid renewable energy in remote Arctic areas: An analysis of the Russian Far East. *Renewable and Sustainable Energy Reviews*, 2016, vol. 59, p. 1029-1037.

[38] Gautam BR, Li F, Ru G. Assessment of urban roof top solar photovoltaic potential to solve power shortage problem in Nepal. *Energy and Buildings*, 2015, vol. 86, p. 735-744.

[39] Jamal T, Ongsakul W, Singh JG. Potential rooftop distribution mapping using Geographic Information Systems (GIS) for Solar PV Installation: A case study for Dhaka, Bangladesh. En *2014 3rd International Conference on the Developments in Renewable Energy Technology (ICDRET)*. IEEE, 2014. p. 1-6.

[40] Rathore PKS, Chauhan DS, Singh RP. Decentralised solar rooftop photovoltaic in India: On the path of sustainable energy security. *Renewable energy*, 2019, vol. 131, p. 297-307.

[41] Ramshani M, Khojandi A, Li X, Omitaomu O. Optimal planning of the joint placement of photovoltaic panels and green roofs under climate change uncertainty. *Omega*, 2020, vol. 90, p. 101986.

[42] Duman AC, Güler Ö. Economic analysis of grid-connected residential rooftop PV systems in Turkey. *Renewable energy*, 2020, vol. 148, p. 697-711.

[43] Goel M. Solar rooftop in India: Policies, challenges and outlook. *Green Energy & Environment*, 2016, vol. 1, no 2, p. 129-137.

[44] Maharaja K, Balaji PP, Sangeeta S. Development of bidirectional net meter in grid connected solar PV system for domestic consumers. En *2016 International Conference on Energy Efficient Technologies for Sustainability (ICEETS)*. IEEE, 2016. p. 46-49.

[45] Dato P, Durmaz T, Pommeret A. Smart grids and renewable electricity generation by households. *Energy Economics*, 2020, vol. 86, p. 104511.

[46] Striuli A. Method and apparatus for managing electric energy produced locally for self-consumption and distributed to multiple users belonging to one or more communities of users. U.S. Patent No 10,559,961, 11 Feb. 2020.

[47] AlepuzS, Busquets-Monge S. Interfacing renewable energy sources to the utility grid using a three-level inverter. *IEEE Transactions on Industrial Electronics*, 2006, vol. 53, no 5, p. 1504-1511.

[48] Akikur RK, Saidur R, Ping HW, Ullah KR. Comparative study of stand-alone and hybrid solar energy systems suitable for off-grid rural electrification: A review. *Renewable and Sustainable Energy Reviews*, 2013, vol. 27, p. 738-752.

[49] Mosinger E. Crafted by crises: Regional integration and democracy in South America. En *Regions and crises*. Palgrave Macmillan, London, 2012. p. 163-179.

[50] Green MR. Justification of economic integration in underdeveloped areas: ALALC. International Forum, 1968, vol. 9, no 2 (34, p. 153-168.

[51] Valdivia MH. The time for the political and sovereign integration of Latin America and the Caribbean. Sociology in its Scenarios, 2005, no 11.

[52] De la Barra X, Dello Buono R A. From ALBA to CELAC toward 'another integration'?. *NACLA Report on the Americas*, 2012, vol. 45, no 2, p. 32-36.

[53] Spieksma FTM., Charpin H. City spore concentrations in the European Economic Community (EEC) IV. Summer weed pollen (Rumex, Plantago, Chenopodiaceae, Artemisia), 1976 and 1977. *Clinical & Experimental Allergy*, 1980, vol. 10, no 3, p. 319-329.

[54] Priede J, Neuert J. Competitiveness Gap of the European Union Member Countries in the Context of Europe 2020 Strategy. *Procedia-Social and Behavioral Sciences*, 2015, vol. 207, p. 690-699.

[55] Vervaele JAE. Mercosur and regional integration in South America. *International & Comparative Law Quarterly*, 2005, vol. 54, no 2, p. 387-410.

[56] Scholvin S, Malamud A. Is there a Geoeconomic Node in South America?: Geography, politics and Brazil's role in regional economic integration. *Working Papers ICS*, 2014.

[57] Malamud A, Schmitter PC. The experience of European integration and the potential for integration in South America. *New Regionalism and the European Union. Dialogues, Comparisons and New Research Directions. London and New York: Routledge*, 2011, p. 135-57.

[58] Fanelli JM, Jiménez JP, López I. Environmental tax reform in Latin America. ECLAC Repository.2015.

[59] Fearnside PM. Impacts of Brazil's Madeira River dams: Unlearned lessons for hydroelectric development in Amazonia. *Environmental Science & Policy*, 2014, vol. 38, p. 164-172.

[60] CEPAL N. U. Formulation of plans for water resource management in Latin America and the Caribbean. 1986.

[61] Mensah L, Obi P, Bokpin G. Cointegration test of oil price and US dollar exchange rates for some oil dependent economies. *Research in International Business and Finance*, Elsevier 2017, vol. 42, p. 304-311.

[62] IRENA. Global Renewables Outlook. Energy Transformation 2050. 2020. Abu Dhabi.

[63] Arango S, Larsen ER. The environmental paradox in generation: How South America is gradually becoming more dependent on thermal generation. *Renewable and Sustainable Energy Reviews*, 2010, vol. 14, no 9, p. 2956-2965.

[64] Olson DM, Dinerstein E. The Global 200: Priority ecoregions for global conservation. *Annals of the Missouri Botanical garden*, 2002, p. 199-224.

[65] Saunders AM, Albertsen M, Vollertsen J, Nielsen PH. The activated sludge ecosystem contains a core community of abundant organisms. *The ISME journal*, 2016, vol. 10, no 1, p. 11.

[66] Ricciardi A, Rasmussen JB. Extinction rates of North American freshwater fauna. *Conservation biology*, 1999, vol. 13, no 5, p. 1220-1222.

[67] AideTM, Grau HR. Globalisation, migration, and Latin American ecosystems. 2004.

[68] Bravo E. Impacts of oil exploitation in Latin America. Biodiversity, 2005, vol. 43, p. 1-9.

[69] Manuschevich D. State investment in forestry research and development against COP-25: Free to choose between native forests and exotic plantations? Geographic Investigations, 2019, no 58, p. 104-118.

[70] Montiel San Martin A. El desarrollo sostenible y la COP25. 2019. p. 5-5.

[71] Del Carmen Llasat M. COP25: un aviso urgente a todas las personas de este planeta. *Razón y fe*, 2020, vol. 281, no 1443, p. 29-42.

[72] Cepal. Social Panorama of Latin America. December 2019.

[73] Cepal. Development and equality: the thinking of ECLAC in its seventh decade. Related texts for the period 2008-2018. 2018.

[74] Cepal. Natural resources, environment and sustainability. 70 years of ECLAC thought. September 2019.

[75] Cepal. Horizons 2030: equality at the center of sustainable development. Synthesis.2016.

[76] Smith DC. COVID-19 and the energy and natural resources sectors: little room for error. 2020.

[77] Veettil BK, Wang S, De Souza SF, Bremer UF. Glacier monitoring and glacier-climate interactions in the tropical Andes: A review. *Journal of South American Earth Sciences*, 2017, vol. 77, p. 218-246.

[78] Cochrane MA, Barber CP. Climate change, human land use and future fires in the Amazon. *Global Change Biology*, 2009, vol. 15, no 3, p. 601-612.

[79] Arango S, Dyner I, Larsen ER. Lessons from deregulation: Understanding electricity markets in South America. *Utilities Policy*, 2006, vol. 14, no 3, p. 196-207.

[80] Rudnick H, Raineri R. Transmission pricing practices in South America. *Utilities Policy*, 1997, vol. 6, no 3, p. 211-218.

[81] Rudnick H. Chile: Pioneer in deregulation of the electric power sector. *IEEE Power Engineering Review (Institute of Electrical and Electronics Engineers);(United States)*, 1994, vol. 14, no 6.

[82] Rudnick H. The electric market restructuring in South America: successes and failures on market design. *Plenary Session, Harvard Electricity Policy Group, San Diego, California*, 1998.

[83] OECD. *Green Growth Indicators 2017*, OECD Green Growth Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264268586-en. 2017.

[84] International Energy Agency IEA. *Monthly OECD electricity statistics*, IEA, Paris. 2020.

[85] BP. Statistical Review of World Energy 2019.

[86] Arango-Aramburo S, Ríos-Ocampo JP, Larsen ER. Examining the decreasing share of renewable energy amid growing thermal capacity: The case of South America. *Renewable and Sustainable Energy Reviews*, 2020, vol. 119, p. 109648.

[87] Organización Latinoamericana de Energía OLADE.Procesos competitivos para el financiamiento de Proyectos de Energías Renovables. Quito 2020.

[88] Barbosa LSNS, Bogdanov D, Vainikka P, Breyer C. Hydro, wind and solar power as a base for a 100% renewable energy supply for South and Central America. *PloS one*, 2017, vol. 12, no 3, p. e0173820.

[89] Bogdanov D, Farfan J, Sadovskaia K. Radical transformation pathway towards sustainable electricity via evolutionary steps. *Nature communications*, 2019, vol. 10, no 1, p. 1-16.

[90] Del Mar Rubio M, Tafunell X. Latin American hydropower: A century of uneven evolution. *Renewable and Sustainable Energy Reviews*, 2014, vol. 38, p. 323-334.

[91] Gkillas K, Gupta R, Pierdzioch C. Forecasting realised oil-price volatility: The role of financial stress and asymmetric loss. *Journal of International Money and Finance*, 2020, p. 102137.

[92] Gould CF, Schlesinger S, Toasa AO, Thurber M. Government policy, clean fuel access, and persistent fuel stacking in Ecuador. *Energy for Sustainable Development*, 2018, vol. 46, p. 111-122.

[93] Clementi L, Carrizo S, Bustos Cara R. La región SUBA, Sur de la Provincia de Buenos Aires, epicentro eólico en Argentina. *Revista Universitaria de Geografía*, 2019, vol. 28, no 1, p. 43-64.

[94] Lucena JAY, Lucena KÂA. Wind energy in Brazil: an overview and perspectives under the triple bottom line. *Clean Energy*, 2019, vol. 3, no 2, p. 69-84.

[95] Icaza D, Salinas C, Moncayo D, Icaza F, Cárdenas A, Tello MA. Production of Energy in the Villonaco Wind Farm in Ecuador, in: 2018 World Eng. Educ. Forum - Glob. 2018: pp. 1–7.

[96] Watts D, Oses N, Pérez R. Assessment of wind energy potential in Chile: A project-based regional wind supply function approach. *Renewable energy*, 2016, vol. 96, p. 738-755.

[97] Kissel JM, Hanitsch R, Krauter SCW. Cornerstones of a renewable energy law for emerging markets in South America. *Energy Policy*, 2009, vol. 37, no 9, p. 3621-3626.

[98] Reporte Banco Interamericano de Desarrollo BID. ¡A todas luces! La electricidad en América Latina y el Caribe 2040. 2019.

[99] Luck M, Landis M, Gassert F. Aqueduct water stress projections: decadal projections of water supply and demand using CMIP5 GCMs. *World Resources Institute*, 2015.

[100] Hansen K, Breyer C, Lund H. Status and perspectives on 100% renewable energy systems. *Energy*, 2019, vol. 175, p. 471-480.

[101] Energy Monitor. Renewable energy in Latin America. Group Economics: Enabling smart decisions. ABN AMRO. 2018.

[102] Irena. Renewable capacity statistics 2020, Abu Dhabi. 2020

[103] Irena. Global energy transformation: A roadmap to 2050, Abu Dhabi. 2019.

[104] CIER. Informative energy synthesis of the CIER countries. Information on the energy sector in countries of South America, Central America and the Caribbean Data 2017. Regional Energy Integration Commission. 2019.

[105] Ministério de Minas e Energia. Empresa de Pesquisa Energética. balanço energético nacional brazilian energy balance. Brazil. 2014. http://www.mme.gov.br

[106] Irena. Renewable energy policy brief: Brazil. 2015. Abu Dhabi.

[107] Regional Observatory of Planning for the Development of Latin America and the Caribbean. Plan of the Homeland 2019-2025 of Venezuela. Caracas. 2019.

[108] UPME. Reference expansion plan Transmission generation 2015-2029. Bogota D.C .; 2016.

[109] Amaya Pineda GA. Análisis de la aplicabilidad técnica de la Ley 1715 de 2014 en el país. 2016.

[110] CADER. Cáamara Argentina de Energías renovables. 2017.

[111] Argentina M from EMR. Renovar, Argentina Renewable Energy Plan 2016-2025. 2016.

[112] Ecodie. CNE: Chile will exceed its renewable energy goals by 2025.

[113] Chile M de E de. Energía 2050. http://www.energia20 50.cl/en/. [Accessed 01 Jun 2020].

[114] Ministry of energy. Government of Chile. Long-term energy planning. 2019 Background Update Report. December 2019.

[115] IRENA. Renewable energy policy brief: Bolivia. 2015. Abu Dhabi.

[116] Política energética de la república del Paraguay. Decreto Nº 6092/2016.

[117] MEM. National energy plan 2014-2025. 2014. Lima.

[118] IRENA. Renewable energy policy brief: Uruguay. 2015. Abu Dhabi

[119] IRENA. Uruguay Power system flexibility assessment. 2018. Abu Dhabi

[120] IRENA. Renewable Energies in Latin America 2015. Policy Summary; 2015.

[121] National Energy Plan 2006-2025 Colombia 2006. http://climatepolicydatabase.org/

[122] https://renewablesnow.com/news/argentine-renewables-increase-production-by-99-yy-in-nov-681318/

[123] http://generadoras.cl/generacion-electrica-en-chile

[124]https://energialimpiaparatodos.com/2019/01/16/bolivia-celebra-5-anos-produciendo-energia-eolica-y-vienen-mas-inversiones/

[125]Banco Interamericano de Desarrollo BID. Red del futuro: desarrollo de una red eléctrica limpia y sostenible para América Latina. 2017.

[126]United Nations Development Programme UNDP. Anual report 2019. Development choises will define future. 2019.

[127] Gestion. Economía. 2019. https://gestion.pe/economia/centrales-solares-peru-cuenta-con-solo-siete-centrales-solares-con-una-potencia-de-24848-mw-noticia/

[128] IEA. *Renewables 2019*, IEA, 2019.Paris.

[129] Presidencia de la República de Uruguay. Comunicaciones. 2019. https://www.presidencia.gub.uy/comunicacion/comunicacionnoticias/energia-uruguay-otegui-miem

[130] ARCONEL, 2015a. El Consejo Mundial de Energía ubica al Ecuador entre los 5 mejores países en Seguridad Energética a nivel mundial.

[131] Ponce-Jara MA, Castro M, Pelaez-Samaniego MR, Espinoza-Abad JL, Ruiz E. Electricity sector in Ecuador: An overview of the 2007–2017 decade. *Energy Policy 2018*, *113*, 513-522.

[132] OLADE. Sistema de Información Energética de Latinoamérica y el Caribe. sieLAC. 2019. Retrieved from http://sielac.olade.org/

[133] Ecuador, B. C. BCE. 2015.

[134] Center for Economic and Social Rights. Rights violations in the Ecuadorian Amazon: the human consequences of oil development. *Health and human rights*, 1994, p. 82-100.

[135] Buccina S, Chene D, Gramlich J. Accounting for the environmental impacts of Texaco's operations in Ecuador: Chevron's contingent environmental liability disclosures. En *Accounting Forum*. Taylor & Francis, 2013. p. 110-123.

[136] Pérez Mora AC. *Las dificultades en la iniciativa ecuatoriana Yasuní-ITT que propone una alternativa para el cambio climático:¿ inexactitudes políticas internas o falta de corresponsabilidad mundial?*. BS thesis. Quito/Puce/2012, 2012.

[137] Torres Castillo TR. *Desarrollo de un modelo de negociación de la iniciativa Yasuní Itt*. BS thesis. Universidad del Azuay, 2014.

[138] Seaman Larco C. Study of the progress of the Yasuni-ITT initiative focused on the mechanisms of economic compensation, environmental and social aspects of the uncontacted peoples in the period 2007-2012. BS thesis. Pontificia Universidad Católica del Ecuador, 2014.

[139] Haro S, Nataly F. Analysis of the "Green Diplomacy" of the Ecuadorian government: Yasuní-ITT case, January 2007 to July 2013. BS thesis. Quito/PUCE/2015, 2015.

[140] Cevallos-Sierra J, Ramos-Martin J. Spatial assessment of the potential of renewable energy: The case of Ecuador. *Renewable and Sustainable Energy Reviews* 81 (2018): 1154-1165.

[141] Jacobs D, Marzolf N, Paredes JR, Rickerson W. Analysis of renewable energy incentives in the Latin America and Caribbean region: The feed-in tariff case. *Energy Policy* 60 (2013): 601-610.

[142] Escobar LRI, Cañarte JSR, Macías LKV. The change in the energy matrix in Ecuador and its impact on the social and economic development of the population. Mikarimin. Multidisciplinary Scientific Journal. *e-ISSN 2528-7842* 3.2 (2017): 25-36.

[143] Peralta J, Lopez A, Barriga A, Sosa I. Statistical analysis of meteorological information for the exploitation of renewable energies in Ecuador.*Conference Paper,(2)*. 2013.

[144] Villacreses G, Gaona G, Martinez-Gómez J, Jijón DJ. Wind farms suitability location using geographical information system (GIS), based on multi-criteria decision making (MCDM) methods: The case of continental Ecuador. *Renewable Energy* 109 (2017): 275-286.

[145] Secretaría Técnica Planifica Ecuador. Plan 2017-2021 Toda una Vida.

[146] CONELEC , 2007a. Consejo Nacional De Electricidad. Evaluación Y Perspectivas Para El Sector 2007–2016.

[147] CONELEC, 2007b. Consejo Nacional De Electricidad. Plan 2007-2016. Quito.

[148] CONELEC, 2013. Consejo Nacional De Electricidad. Plan 2013–2022. Quito.

[149] Ayala M, Maldonado J, Paccha E, Riba C. Wind power resource assessment in complex terrain: Villonaco case-study using computational fluid dynamics analysis. *Energy Procedia* 107 (2017): 41-48.

[150] Jijón D, Constante J, Villacreses G.. Modelling of performance of 2 MW wind turbines in Ecuador: Electric-wind potential Estimación del rendimiento de aerogeneradores de 2 MW en el Ecuador: Potencial Eolo-Eléctrico. *Potencia (kW)*, vol. 4, p. 0.

[151] Eras-Almeida AA, Egido-Aguilera MA. Quality Control Applied to the Photovoltaic Systems of the Galapagos Islands: The Case of Baltra and Santa Cruz. *Power (Wp)* 265 (2018): 250.

[152] Constituent Assembly of Ecuador. Constitution of the Republic of Ecuador. Quito: Constitutional Court of Ecuador. Official Register No. 449. 2008.

[153] Gregor Barié C. New constitutional narratives in Bolivia and Ecuador: good living and the rights of nature. Latin America. Journal of Latin American Studies 59 (2014): 9-40.

[154] Gómez Rodríguez GV, Chou Rodríguez R. Ecuador facing sustainability in the 21st century: energy efficiency law. bolivarian identity 3.1 (2019): 1-8.

[155] Jaramillo W E. Electric taxis in the city of Loja-Ecuador. Spaces. 2019.

[156] Paredes LA. Electromovilidad y Eficiencia Energética en el Transporte Público de Pasajeros del Ecuador Continental. *Revista Técnica Energía* 16.1 (2019).

[157] Quintanilla González TE. *Desarrollo un plan estratégico de comunicación para el posicionamiento del tranvía como un sistema de transporte eficiente en Cuenca*. MS thesis. Quito: Universidad de las Américas, 2014., 2014.

[158] Martínez J., Martí-Herrero J, Villacís S, Riofrío AJ. Analysis of energy, CO2 emissions and economy of the technological migration for clean cooking in Ecuador. *Energy Policy* 107 (2017): 182-187.

[159] Purcell TF, Fernandez N, Martinez E. Rents, knowledge and neo-structuralism: transforming the productive matrix in Ecuador. *Third World Quarterly* 38.4 (2017): 918-938.

[160] Sovacool BK, Scarpaci J. Energy justice and the contested petroleum politics of stranded assets: Policy insights from the Yasuní-ITT Initiative in Ecuador. *Energy Policy*, 2016, vol. 95, p. 158-171.

[161] Finer M, Morcel R, Jenkins CN. Leaving the Oil Under the Amazon: Ecuador's Yasuní-ITT Initiative. *Biotropica*, 2010, vol. 42, no 1, p. 63-66.

[162] Bass MS, Finer M, Jenkins CN, Kreft H. Global conservation significance of Ecuador's Yasuní National Park. *PloS one*, 2010, vol. 5, no 1, p. e8767.

[163] Operador Nacional de Electricidad CENACE. Balance anual de Energía 2019. 2020.

[164] Operador Nacional de Electricidad CENACE. Balance anual de Energía 2018. 2019.

[165] Diario El Comercio. Abril de 2019.

[166] ELECAUSTRO. Proyecto Eólico Minas de Huascachaca [WWW ⟨https://www.elecaustro.gob.ec/proyectos/proyecto-eolico-minas-de-huascachaca/⟩ 2020. (Accessed 12 Jun 2020).

[167] CELEC. Nuevos proyectos de energía removable. 2020.

[168] MEER. Plan 2016–2035.

[169] CONELEC. Perspectiva y expansion del Sistema eléctrico ecuatoriano. Dic. 2015. Vol 3.

[170] INER— Perspectiva del Ecuador al 2050. Quito, Ecuador, 2016.

[171] MICSE- Agenda nacional de energía 2016–2040; Quito-Ecuador. 2016.

[172] ARCONEL Statistics of the Ecuadorian Electricity Sector, March 2020. Quito-Ecuador.

[173] Golla S, Gerke SJ. First complete and sustainable Energy Transition Study for Ecuador “The End of Oil” Primer estudio para una transición energía sostenible del Ecuador “El fin del Petróleo”. Revista Energía. 2018