Publisher: Sapienza Grupo Editorial
R. Santa Cruz, 2187, Vila Mariana
São Paulo, Brazil
editor@sapienzaeditorial.com

Sapienza
International Journal of Interdisciplinary Studies
ISSN: 2675-9780

Solar panels as an energy saving alternative in the Monteverde maritime dock, Santa Elena, Ecuador

Painéis solares como uma alternativa de economia de energia no porto marítimo de Monteverde, Santa Elena, Equador

Los paneles solares como alternativa de ahorro energético en el muelle marítimo Monteverde, Santa Elena, Ecuador

Edgar Rolando Villamarín-Tapia
https://orcid.org/0000-0003-1193-1858
Graduate Institute, Master in Mechanics, Energy Efficiency Mention, Technical University of Manabí, Ecuador.
evillamarin4014@utm.edu.ec (correspondence)

Jesús Alberto Pérez-Rodríguez
https://orcid.org/0000-0002-1578-2565
Graduate Institute, Master in Mechanics, Energy Efficiency Mention, Technical University of Manabí, Ecuador.
jesus.perez@utm.edu.ec

Ciaddy Gina Rodríguez-Borges
https://orcid.org/0000-0003-1097-4194
Graduate Institute, Master in Mechanics, Energy Efficiency Mention, Technical University of Manabí, Ecuador.
ciaddy.rodriguez@utm.edu.ec

ARTICLE HISTORY

Received: 13-01-2023
Revised Version: 26-03-2023
Accepted: 30-03-2023
Published: 31-03-2023

Manuscript type: Article

ARTICLE INFORMATIONS

Science-Metrix Classification (Domain):
Applied Sciences
Main topic:
Energy saving
Main practical implications:
This study presents evidence to implement an energy transition plan using solar panels as clean energy.
Originality/value:
Due to the lack of studies addressing this topic in Ecuador, the study represents high relevance for science and policymakers in energies.

ABSTRACT

The objective of this study was to analyze solar panels as an energy saving alternative in the Monteverde Maritime Dock, Santa Elena, Ecuador. Methodology: The type of research was quantitative, descriptive and field, with the support of a bibliographic-documentary study. The population consisted of 10 participants. The data collection technique used was the survey and the instrument was a questionnaire type Likert scale. Data processing was carried out using descriptive statistics. Results: 50% of those surveyed agree with the use of renewable energies; 60% indicate that traditional or conventional sources of energy are the most used; 60% consider the installation of photovoltaic technology possible; 70% consider it profitable to invest in solar panels in lighting systems on the dock and its buildings. Conclusion: applying a gradual approach to the use of photovoltaic technology, it is possible to incorporate solar panels in buildings and for external lighting of the Santa Elena Maritime Dock, since the radiation conditions, regulations, economic resources and trained personnel exist, only the will is needed to execute the pertinent actions in favor of environmental and social responsibility.

Keywords: Solar panels, energy saving, sea dock, Ecuador.

RESUMO

No final de 2019, iniciou-se uma pandemia que trouxe consigo importantes mudanças na saúde física e mental dos seres humanos. Os estados de confinamento fazem com que as pessoas, especialmente os jovens, mudem seus métodos de relacionamento e estudo. Considerando que a juventude traz consigo mudanças emocionais, culturais e sociais, é importante saber como essa pandemia pode aprofundá-las ainda mais. Objetivo: Conhecer a prevalência de deterioração do padrão de sono em alunos de Enfermagem da UTA pós-COVID-19 no ano letivo de outubro de 2022 a março de 2023. Metodologia: Recolheram-se dados de uma amostra probabilística de 275 alunos através de um questionário online. Aqui, informações sociodemográficas foram coletadas e dois instrumentos validados foram usados: o índice de gravidade da insônia e a escala de sonolência de Epworth. Resultados: Mostra-se que 83,64% dos participantes apresentaram pelo menos um distúrbio leve do sono. 76,4% dos alunos avaliados apresentaram algum problema de insônia e 57,1% têm problemas de sonolência diurna. Foi identificada uma correlação estatisticamente significativa entre os resultados desses dois questionários e que as mulheres têm uma leve tendência a sentir sonolência em relação aos homens. Conclusão: Os resultados e a literatura sugerem que os distúrbios do sono são gerados pela má organização do tempo dos alunos. Apesar disso, o confinamento pode ser um agravante dessa condição, podendo desencadear outros transtornos.

Palabras clave: Painéis solares, economia de energia, porto marítimo, Equador.

RESUMEN

Este estudio tuvo como objetivo: analizar los paneles solares como alternativa de ahorro energético en el Muelle Marítimo Monteverde, Santa Elena, Ecuador. Metodología: El tipo de investigación fue cuantitativa, de tipo descriptivo y de campo, con apoyo de un estudio bibliográfico-documental. La población estuvo conformada por 10 participantes. La técnica de recolección de datos empleada fue la encuesta y el instrumento un cuestionario tipo escala Likert. El procesamiento de los datos se llevó a cabo mediante la estadística descriptiva. Resultados: un 50% los encuestados están de acuerdo con el uso de las energías renovables; 60% indica que las fuentes tradicionales o convencionales de energía son las más usadas; 60% considera posible la instalación de tecnología fotovoltaica; 70% considera rentable la inversión en paneles solares en los sistemas de iluminación en el muelle y sus edificaciones. Conclusión: aplicando un enfoque gradual de utilización de tecnología fotovoltaica, es posible la incorporación de paneles solares en las edificaciones y para el alumbrado externo del muelle Marítimo de Santa Elena, pues existen las condiciones de radiación, normativas, recursos económicos y personal capacitado, solo hace falta la voluntad para ejecutar las acciones pertinentes en pro de la responsabilidad ambiental y social.

Palavras-chave: Paneles solares, ahorro energético, muelle marítimo.

INTRODUCTION

It is a globally recognized fact that over time, the pollution of the natural environment has been contributing significantly to the planetary deterioration and environmental outcomes that humanity witnesses today. Hence, broad sectors of the world that have in common their interest in the protection, care and restoration of terrestrial ecosystems, in an effort to contribute to find an answer to this problem opened a path through renewable energy sources, as alternatives to the use of fossil fuels such as oil, coal and natural gas.

As is well known, the planet is currently facing a climate crisis due to the increase in anthropogenic emissions of greenhouse gases (GHG), as a consequence of the way in which humanity has developed so far Liberona, (2020) that is, favoring growth and development based on the extraction and processing of natural resources, which demand high energy consumption, for which fossil fuels have been increasingly burned (Liberona, 2020).

Mention should be made of the study published by the Copernicus Climate Change Service (C3S) of the European Union, which reveals that, in the year 2020, atmospheric concentrations of greenhouse gases: carbon dioxide (CO_2) increased by 0.6% and methane (CH_4) increased by almost 0.8%. It is estimated that they were at their highest point in 2003, when satellite observations began (C3S, 2021).

The above is reinforced in the report issued by the World Energy Organization (IEA) where it underlines that globally in 2021 global carbon dioxide emissions (CO_2) increased by 5%, very close to the historical peak of emanations of the gas in the period 2018-2019 (IEA, 2021). At this point, it can be noted that, as the predominant energy source, fossil fuels collectively accounted for 86.2% of total energy consumption during 2009-2018 (Looney, 2020). Only 13.8% of energy consumption during 2009-2018 came from renewable or alternative energy sources, with hydropower accounting for almost half (Looney, (2020). After observing the results of the research work developed by the aforementioned authors and several organizations located around the world, which share the concern for the sustained deterioration process that the planet has been experiencing for many years and, especially for the role that fossil fuels have been playing in this matter, as Liberona emphasizes, (2020) "it is imperative to stop the use of fossil fuels and move towards the use of clean energies" (p. 7). All this, in order to reverse the significant deterioration of nature caused by industrial activities based on the use of polluting energies.

Emphasizing industry, one of the most dynamic sectors of the economy, the International Energy Agency (IEA) estimates that industry as a whole consumes more than 40% of the world's electricity. Other sectors include agriculture, commercial and public services, residential consumption and other unspecified uses (IEA, 2007). Therefore, it is possible to state that in both industrialized and developing countries there are still many facilities whose main source of energy supply is fossil fuels. Thus, the fuels most consumed by this productive segment are coal (78%) and oil (9.4%) (IEA, 2007). This leads us to say that a substantial change is required in the use of energy, which should be oriented, as has been emphasized from different perspectives, to the use of less polluting, cleaner and more environmentally friendly energy sources.

Focusing on the maritime industry, a sector that is linked to this research, it is worth highlighting what the Maritime Transport Research Group of the Foundation of the University of Oviedo (2008) states about the fact that the evolution of the international economy, the volume of world trade and the cycles of the shipbuilding industry have caused an exponential growth in ports. But, at the same time, these activities especially cause the constant expansion of ports to have a significant impact on the environment (Larrea, 2022). Consequently, and in the understanding of the responsibility that they are directly obliged to fulfill due to regulatory frameworks, port administrations must establish actions that, in Larrea's opinion, (2022) allow them to achieve environmental sustainability and help other links in the logistics chains in this task, such as maritime transport or road transport.

In view of the above, as part of these efforts, according to Larrea (2022), energy efficiency and electrification of port equipment can be promoted in maritime terminals and the development of renewable energy infrastructure can be encouraged. At this point, solar panels can become an alternative for energy saving in maritime terminals and, in particular, the Monteverde Maritime Pier, Santa Elena, Ecuador, is mentioned, since it constitutes the environment of this research. Framed with this, it should be noted that the privileged geographical location of Ecuador, makes it a region with a great potential for constant solar radiation throughout the year, which undoubtedly can be exploited for photovoltaic power generation projects.

With all these points, this research work is born in the interest of contributing to provide knowledge that can serve to seek energy saving solutions and raise awareness about environmental care, which is in line with reducing GHG emissions, because in recent years there is a perception in the community that the natural environment has deteriorated and especially the maritime dock environment that is a substantial part of the economy and the development of the productive activities of the country and this Ecuadorian province in particular, has not been immune to this phenomenon. These statements are supported by the report of Mundo Marítimo, (2019), when it states that actions must be taken for the terminal to function

properly, among other measures include: reducing environmental emissions and it is there, where energy saving can contribute greatly. For this reason, the general objective of this research is to analyze solar panels as an energy saving alternative at the Monteverde Maritime Pier, Santa Elena, Ecuador. This reflection will allow the responsible and/or institutional entities to design strategies and make decisions regarding the aspects identified.

Theoretical Basis

Photovoltaic Solar Energy

It is a technology that generates direct current (power measured in watts or kilowatts) by means of semiconductors when they are illuminated by a beam of photons. As long as light strikes a solar cell, which is the name given to the individual photovoltaic element, electrical power is generated; when the light is extinguished, the electricity disappears (Alonso et al, 2007). Like any technology, photovoltaic solar energy has certain advantages and disadvantages, which are mentioned below.

Table 1. Advantages and Disadvantages of photovoltaic solar energy

Advantages	Inconveniences
Clean, renewable, infinite, silent	Large initial investment
Economic retribution for production for sale to the grid	Difficult to store
Subsidies	Complex and expensive module manufacturing process
Short energy pay-back	Not competitive with other energies at present.
No modular moving parts	Variable production according to weather and time of the year

Source: Alonso et al (2007)

According to the Economic Commission for Latin America and the Caribbean (ECLAC), solar energy, although it has grown widely, only a very small fraction of potential users: homes, businesses, industries, schools and public buildings, currently have solar roofs (photovoltaic panels) (ECLAC, 2020). Hydroelectricity continues to be the most widely used renewable resource, but much attention must be paid to the adequate mitigation of environmental and social impacts and the participation of communities. This will be the key to obtaining licenses for future water projects (ECLAC, 2020).

Solar Panels

Photovoltaic panels are devices that perform the function of transforming the radiation coming from the sun that passes through the atmosphere into useful energy (Bitar & Chamas, 2017). In another definition, Aguirre, (2018) indicates that it is the set of small cells composed mainly of crystalline silicon or gallium arsenide (semiconductor materials) that convert light into electricity by means of a photovoltaic effect.

These tools provide several advantages, which can be summarized according to Bitar & Chamas, (2017) as follows: a) low maintenance cost; b) generation of zero harmful emissions to the environment and; c) feasibility of installation and coupling with existing energy sources at the installation site. According to Aguirre, (2018), there are a variety of cells from which solar panels are made, but the most well-known in the market are: mono-crystalline silicon cells; poly-crystalline silicon cells and thin film cells.

In order to obtain the highest efficiency from the solar panels, the inclination and orientation at the time of installation must be taken into account. If the loads are small it is common to install them in a fixed position; if these are large, the installations have solar tracking systems that rotate according to the location of the sun, taking better advantage of the solar resource and also increasing the cost of the installation. The orientation of the panels will always be the opposite to the hemisphere where they are installed (Aguirre, 2018). To determine the most suitable separation distance to install solar panels for their highest efficiency, Aguirre, (2018), the following mathematical equations are used:

Minimum angle of the sun's position with respect to the observer**.**

$$\gamma = 90 - \delta - L$$

Equation 2. Distance adjacent to the set tilt angle

$$d1 = w * Cos(\beta)$$

Equation 3. Height at which the panel of the surface is located by inclination placed

$$h = d1 * Tan(\beta)$$

Equation 4. Panel shadow generation distance

$$d2 = \frac{h}{Tan(\delta)}$$

Equation 6. Minimum distance between panels

$$d = d1 + d2$$

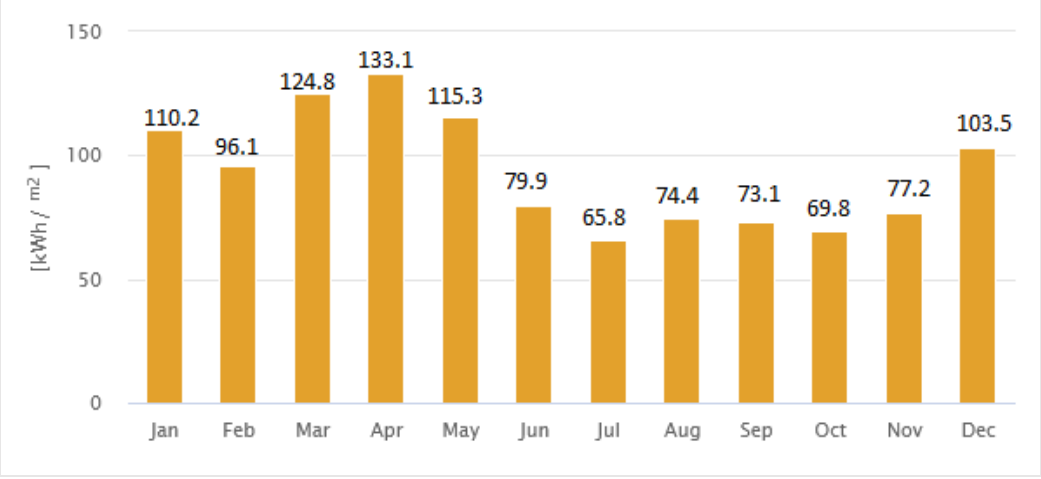
Where:

- γ = Smallest angle of the sun's position with respect to the observer.
- δ = inclination of the earth with respect to the sun the one with the smallest angle.
- L = Latitude
- β = Inclination of PV panels
- d = Minimum distance between PV panels

Energy Efficiency in Maritime Transportation

Research conducted on energy efficiency in shipping, as highlighted by the authors (Fridel et al, 2013), covers alternative sources, operational, technical and structural measures for energy savings and emissions abatement. In order to achieve this goal, Ecuador has been promoting for some years now the Change of the Energy Matrix, which consists of increasing the power or electric energy generation capacity in an efficient and environmentally clean way (Guastay & Llanes, 2020). Thus, according to the Agency for Regulation and Control of Energy and Non-Renewable Natural Resources (ARCERNR) of Ecuador, the country has an effective installed capacity of renewable energy sources, which corresponds to the participation of the hydraulic source in 96.9% and only 3.1% corresponds to wind, solar and biomass energy together (ARCERNR, 2021). Due to their location, ports can play a fundamental role in the decarbonization agenda of countries and, in particular, of international logistics chains and facilitate economic growth between regions and countries (Larrea, 2022).

Figure 1. Average Normal Direct Irradiance Indicator



Source: Data expressed in kWh/m2. Solar radiation, Global Solar Atlas, 2022 (https://globalsolaratlas.info/detail?c=-2.066214,-80.749726,11&s=-2.066214,-80.749726&m=site)

Photovoltaic Energy in Ecuador and in the Province of Santa Elena

According to estimates by the National Electricity Council (CONELEC) and the Energy Research Corporation (CIE), the approximate average value of global solar radiation in Ecuador is 4.575 Wh/m^2 /day CONELEC & CIE, (2008), throughout the national territory and in some places it is higher than 5 kWh/m^2 day (one of the highest values in the world) (Velasco & Cabrera, 2010). In this last group of Ecuadorian localities with high solar radiation, the Santa Elena area can be included, since the graph shows the average monthly irradiation expressed in kWh/m2, where the month of July has the lowest irradiation, while the month of April has the highest solar incidence index in the sector under study, with an average solar irradiation of

93.6 kWh/m2.

Thus, according to Muñoz et al (2018) the estimated solar potential for electricity generation purposes in the country is 312 GW equivalent to 456 TWh per year or 283 MBEP (million barrels of oil equivalent) per year. This value is approximately equivalent to fifteen (15) times the country's technical and economically exploitable hydroelectric potential (Muñoz et al, 2018). Taking into consideration this solar potential, Ecuador has implemented policies to reduce the emission of polluting gases, modifying its energy matrix to take advantage of its climatic and geographical conditions, seeking to implement the use of renewable energies such as photovoltaic (Navas et al, 2022).

METHODS

The methodology used in this research is the quantitative approach, which according to Hernandez et al (2006), has the characteristic of choosing an idea, which is transformed into one or several relevant research questions; after these variables are derived and studied within a specific context, the measurements obtained are analyzed through statistical methods and conclusions are drawn. In the same way, information was compiled in relation to the general data on the characterization of photovoltaic energy in Ecuador and specifically in Santa Elena and its possible use as an alternative energy to the use of fossil fuels, which was analyzed by means of documentary analysis. In the opinion of Finol & Nava (2001), documentary research "constitutes an activity that is developed in any environment where information, observations, evaluations, analysis and interpretations can be obtained and in which the personal contribution represents a quota of participation in the development of the research" (p.26). Additionally, these authors state that this task leads to the production of new knowledge, proposals, comparisons and generalizations about the subject of study (Finol & Nava, 2001).

The application of the quantitative approach is carried out with the aim of analyzing in the best possible way, the relationship that may exist between the use of solar panels as an alternative for energy savings in the Maritime Pier of the Liquefied Petroleum Gas (LPG) Plant in Santa Elena, Ecuador, since, as already pointed out in the previous lines, Ecuador is immersed in an energy transition, hence, if the transportation that involves the commercialization of fossil fuels is carried out with clean energy, in this case photovoltaic, it can partially offset the GHG emissions derived from these polluting products.

Place of study

The Monteverde Maritime Terminal Pier (TMV), which is located in the province of Santa Elena (bordered by the province of Guayas to the north, east and south, and the Pacific Ocean to the west), in the town of Monteverde, 40 km north of the city of Salinas and 27 km from the city of Santa Elena.

Figure 2. Geographical location of the Monteverde Maritime Terminal Pier

Source: Mindiola & Recalde, (2008)

Type of research

The design of the research exercise is descriptive and field-based, since its purpose is to describe the levels of the variable in a real context without manipulating it. According to Hernández et al, (2006), description is understood as the process by which different elements of the variables are evaluated in order to specify the most relevant properties of the studied phenomenon based on its characteristics, in this case of solar panels as energy saving alternatives. On the other

hand, it is pointed out that the present research is Field, according to Palella & Martins, (2012) "data collection is carried out directly from the reality where the facts occur, without manipulating or controlling variables, that is, it studies the phenomena in their natural environment" (p.88). In this particular case, the research was carried out at the Monteverde Maritime Pier, Santa Elena, Ecuador.

Population and Sample

For the present investigation, it was determined that the population would be made up of the workers involved in the operations of the Monteverde Maritime Pier, Santa Elena, Ecuador, linked to the problem under study and who are determinant in the resolution of the same, that is, the Maritime Operations Supervisor (2), Industrial Safety Supervisor (1); maritime operations personnel (5) and Maintenance Department Supervisor (2); for a total population of 10 people, who gave their informed consent to participate in this investigation.

According to Hernández et al, (2014) the population is: "the set of all cases that match certain specifications" (p.174). Therefore, the researcher must know it, define it and determine it, as this will allow him/her, among other activities, to consider the elements that may be more representative of the phenomenon in order to plan the data collection.

Regarding the sample, Palella & Martins (2012:), point out that the researcher has two ways to carry out his study, "to cover the entire population, which means taking a census or census-type study, or to select a certain number of population units, i.e., to determine a sample" (p.105). Taking into account these approaches, in this research it was decided to take the totality of the population, because it is finite, small and easily accessible, for the collection of information.

Data Collection Techniques and Instruments

The data collection techniques used in the development of this research were: direct observation, survey and online documentary review of reliable databases such as Google Scholar, publications of indexed journals such as Scielo, Redalyc, Dialnet; digital libraries of both national and international universities, digital repositories of organizations such as ECLAC, IEA, IOE, among other sources. In this regard, Hurtado (2000) defines documentary observation as "a technique in which written information is used, either in the form of data that may have been the product of measurements made by others, or as texts that in themselves constitute the events under study" (p. 427).

Regarding direct observation, Hernández et al, (2006) state that observation consists of the systematic, valid and reliable recording of behaviors or manifested behaviors, taking into consideration verbal and non-verbal communications and that it is a non-obstructive measurement technique. Regarding the survey, it is defined Palella & Martins, (2012) as: "a technique intended to obtain data from several people whose opinions are of interest to the researcher". The instrument used by this technique is the questionnaire, which, according to Hernández et al, (2006) is perhaps the most widely used for data collection; it consists of a set of questions regarding one or more variables to be measured.

In addition, the Likert-type scaling was used; this scale, according to Hernández et al. (2006), consists of a set of items presented in the form of statements or judgments to which the reaction of the subjects to whom it is administered is requested. With a number of categories of 4 responses, which are classified as: always, almost always, almost never, never; with the questions having a positive or favorable direction. In addition, it is important to note that "always" has the highest score on the scale, i.e., that the respondent, when scoring with this score, performs or acts favorably in response to the question asked.

Validity and reliability

The validity of the content of the present research was carried out by means of the judgment of experts on this point, according to Palella & Martins, (2012) "validity is defined as the absence of bias. It represents the relationship between what is measured and what is actually intended to be measured" (p.160). The assessment of the experts in the subject matter issues their comments in this regard, they verify the concordance of the different items and unit of analysis with their theoretical content, thus, they gave the validation of the instrument, in terms of content, criterion and statistical, to then carry out the study of the results obtained.

On the other hand, the reliability of an instrument, according to Hernández et al, 2006), "refers to the degree to which its repeated application to the same subject or object produces the same results" (p. 346). In this sense, to determine the degree of reliability of this instrument, a pilot test was conducted with 10 public officials different from the key subjects, but with similar characteristics. Following the thread of ideas, the pilot test according to Malhotra et al, (2004), refers to the application of the questionnaire in the previously calculated sample, which will yield the number of respondents to identify and eliminate possible problems. In this way, the details or defects that the questionnaire may have, can be modified before the final test. The Cronbach's Alpha Coefficient was used to measure the reliability of the questionnaire. Once the pilot test was conducted, the Cronbach's statistic gave a value of 0.87, a figure that reflects a high reliability according to (Palella & Martins, 2012). Thus, the instrument was ready to be applied to the entire population.

Data Processing and Analysis Techniques

The data collected in this study, once the instrument developed for this purpose had been applied, were analyzed using descriptive statistics, since quantification and statistical treatment made it possible to reach pertinent conclusions in relation to the subject matter addressed by the researcher. Hernández et al (2006) defines this technique as the description of the data in order to analyze and relate them to each other and to their variables. The values obtained were satisfactorily consolidated within several frequency distribution data tables.

RESULTS AND DISCUSSION

Analysis and Interpretation of Results

At the beginning of the survey, the questions were aimed at diagnosing the current situation regarding the use of renewable energy sources at the LPG maritime terminal in Monteverde Do you agree with the current trends towards the use of renewable energy sources for the protection of the environment at the LPG maritime terminal in Monteverde?

Table 2. Frequency distribution of the respondents of the LPG maritime terminal in Monteverde, Santa Elena, Ecuador, regarding the question: Do you agree with the current trends towards the use of energy from renewable sources for the protection of the environment in the LPG maritime terminal in Monteverde?

Alternative	Frequency (F)	Percentage (%)
Always	5	50%
Almost always	3	30%
Almost never	1	10%
Never	1	10%
TOTAL	10	100%

Source: The author (2022) data obtained from the application of the data collection instrument.

From the results obtained, 50% of the respondents reported that they always agree with the current trends towards the use of renewable energy sources for environmental protection at the LPG Marine Terminal in Monteverde, 30% almost always, 10% almost never, and finally 10% never.

From this it can be inferred that most of the participants recognize the essential importance of the use of clean energies for the preservation of the natural environment and apply it within the institution, however, 20% of the participants state that they almost never or never agree with the use of renewable energy sources, thus inferring that these people consider that the use of traditional or conventional energies contribute in their daily activities to the achievement of organizational objectives, since paradoxically they work in a scenario based on energy sources associated with the use of hydrocarbons such as LPG.

These statements are aligned, with what Poveda et al, (2017) state in their study, regarding the fact that the energy issue has become a priority factor at the international level due to the strategic importance of ensuring full and timely energy supply in an environmentally compatible manner. These authors also state that Ecuador is doing an outstanding job in this aspect.

Table 3. Frequency distribution of the respondents of the LPG Maritime Terminal in Monteverde, Santa Elena, Ecuador, regarding the question: What do you consider to be the predominant energy source to carry out the activities at the LPG Maritime Terminal in Monteverde?

Alternative	Frequency (F)	Percentage (%)
Traditional or conventional sources	6	60%
Hydraulic source	4	40%
Solar, wind and biomass energy sources	0	0%
Other	0	0%
TOTAL	10	100%

Source: The author (2022) data obtained from the application of the data collection instrument.

About 60% of the respondents indicated that traditional or conventional sources are used to carry out activities related to port activities, while 40% responded that hydraulic energy is the most used in dock operations, 0% indicated that solar, wind and biomass energy sources are not used in the processes carried out in this institution, and another 0% mentioned that other alternative energy sources are not used.

Consequently, it can be inferred that for most of the respondents, the greatest expenditure is distributed between traditional or conventional energy sources (60%) and hydropower (40%). In accordance with this, Wilmsmeier, (2014) revealed that in Latin America and the Caribbean most of the energy used is generated, precisely, from these fuels, while, on average barely 30% of the energy used in container terminals is electric.

Likewise, Guastay & Llanes, (2020) Ecuador has traditionally been supplied with renewable hydroelectric energy combined with a percentage of thermal energy (non-renewable) from fossil fuels. This has to do in part with the nature of the activities developed in the industrial sector. In this regard, Araujo & Lizaldes, (2015), estimate that energy consumption in the dock stage is of great importance due to the amount of operations carried out in the port, which in turn means large energy consumptions.

In this way they point out that the operations that are handled at the dock, to handle loading, unloading and transfer cargo, require handling cranes and different equipment that consume a large amount of fuel (diesel). These cranes generate significant CO_2, emissions, which causes the environmental problems described in previous sections. Likewise, lights and buildings also contribute to the port's energy consumption and, therefore, to its emissions (Larrea, 2022).

In this regard, one of the alternatives aimed at reducing the use of polluting energy sources at the Monteverde dock in Santa Elena, Ecuador, is, especially, photovoltaic solar energy, given the existing potential in the area. In line with this, Larrea, (2022) says that the improvement of the energy efficiency of the operations in the port area can be achieved through, among others, the generation of renewable energy for the operation, for example, wind turbines in port areas, solar panels in port buildings.

This part of the research presents the results related to the planning of projects related to the use of photovoltaic energy at the LPG Maritime Terminal in Monteverde, Santa Elena, Ecuador.

Table 4. Frequency distribution of the respondents of the LPG Maritime Terminal in Monteverde, Santa Elena, Ecuador, regarding the question: Do you consider that high-performance photovoltaic plants can be installed in the area to improve energy efficiency and at the same time protect the environment?

Alternative	Frequency (F)	Percentage (%)
Always	6	60%
Almost always	3	30%
Almost never	1	10%
Never	0	0%
TOTAL	10	100%

Source: The author (2022) data obtained from the application of the data collection instrument.

From the results obtained, 60% of the respondents indicated that they always consider that, in the Monteverde Maritime Pier area of Santa Elena, high-performance photovoltaic plants can be installed to improve energy efficiency and at the same time protect the environment; 30% indicated the option almost always; 10% chose the alternative almost never and 0% never.

From this it can be inferred that the majority of respondents, 90%, if the most chosen alternatives are added, recognize the potential of the territory to implement projects for the use of solar energy. In this framework, the geographical location of the country in relation to the sun can be considered privileged, due to the fact that in Ecuador sunlight is received constantly Grijalva & Vélez, (2020), the sun's rays are received perpendicularly and at a defined angle, all these conditions favor the use of this energy source through photovoltaic systems (Grijalva & Vélez, 2020).

All of which creates the ideal scenario to apply a gradual approach to install solar panels on the dock facilities and buildings, as a solution aimed primarily at reducing fossil fuel consumption, minimizing GHG emissions, and increasing the use of clean energy sources, measures that will provide the port with a large number of economic and environmental benefits in the future.

Table 5. Frequency distribution of the respondents of the LPG Maritime Terminal in Monteverde, Santa Elena, Ecuador, regarding the question: Is the installation of solar panels in the lighting systems of the dock and its buildings considered among the short or long term goals?

Alternative	Frequency (F)	Percentage (%)
Always	4	40%
Almost always	3	30%
Almost never	2	20%
Never	1	10%
TOTAL	10	100%

Source: The author (2022) data obtained from the application of the data collection instrument.

About 40% of the respondents indicated that they always establish in the short or long term goals to consider in the planning the installation of solar panels in the lighting systems in the port and buildings of the LPG maritime terminal in Monteverde, Santa Elena, Ecuador, 30% almost always, 20% almost never and 10% never. The results obtained reflect that the majority of the respondents are convinced that 70% (if the answers with the highest percentage are added) that in the short or long term they intend to use solar panel technology in the dock. Another percentage (30%) indicates that the installation of these systems is almost never or never considered in the future, which is in contrast to what Grijalva & Vélez (2020) stated about the fact that within the framework of energy efficiency and savings in the country, two ways have been proposed to achieve this purpose; the first consists of conscious savings by the population and the second option corresponds to the use of alternatives that allow taking advantage of other sources of energy such as solar energy and through the different existing mechanisms to convert it into electric energy.

Likewise, Article 413 of the Constitution of the Republic of Ecuador establishes that the State must promote energy efficiency, the development and use of environmentally clean and healthy practices and technologies, as well as renewable, diversified, low-impact energies (Pástor, 2019). This segment presents the results on the economic, financial and administrative factors that influence the decision making process on the profitability of the installation of photovoltaic panels at the LPG maritime terminal in Monteverde, Santa Elena, Ecuador, regarding the question: Do you consider that the institution has the trained personnel to calculate the profitability of photovoltaic systems?

Table 6. Frequency distribution of the respondents of the LPG Maritime Terminal in Monteverde, Santa Elena, Ecuador, regarding the question: Do you consider that the institution has made calculations to know how profitable the photovoltaic systems are, since it is one of the short or long term goals?

Alternative	Frequency (F)	Percentage (%)
Always	7	70%
Almost always	3	30%
Almost never	0	0%
Never	0	0%
TOTAL	10	100%

Source: The author (2022) data obtained from the application of the data collection instrument.

Of the total number of respondents, 70% indicated that the institution always has the calculation of the profitability of the photovoltaic systems, 30% almost always, 0% almost never, and 0% for never. It is evident that most of the respondents selected the alternatives of always and almost always, therefore, it is deduced that the trained personnel of the institution has made the quantification of the profitability of the photovoltaic systems that can be installed and used to improve energy efficiency in the LPG Maritime Terminal in Monteverde, Santa Elena, Ecuador.

To calculate how profitable photovoltaic systems are, several parameters are taken into account: installation price, annual savings, this last aspect includes elements such as the power generated by the photovoltaic system; the price of electricity; the cost of installation and tax incentives, among others. Prado, (2020) complements this information by indicating that an analysis of the components of the photovoltaic generation system and an energy study of the joint operation of such elements should be carried out. He also points out that different computational tools can be used for the simulation of the electric system to establish criteria for the techno-economic analysis that allows evaluating the costs involved to generate electric energy, and thus determine if the established electric structure reaches an optimal profitability.

Table 7. Frequency distribution of the respondents of the LPG maritime terminal in Monteverde, Santa Elena, Ecuador, regarding the question: Do you consider that the installation of a photovoltaic system is profitable in the maritime terminal?

Alternative	Frequency (F)	Percentage (%)
Always	7	70%
Almost always	3	30%
Almost never	0	0%
Never	0	0%
TOTAL	10	100%

Source: The author (2022) data obtained from the application of the data collection instrument.

Approximately 70% of the respondents indicated that the institution always has a calculation of the profitability of photovoltaic systems, 30% almost always, 0% almost never, and 0% never. It can be deduced that most of the participants consider possible the installation of photovoltaic technology to improve energy efficiency in the LPG Maritime Terminal in Monteverde, Santa Elena, Ecuador.

Photovoltaic technology initially has a high capital investment cost Alonso et al, (2007), but represents multiple advantages that make it possible to recover the investment in the long term, associated with the fact that it represents a clean energy Alonso et al, (2007), which contributes to the protection of the environment. Also, Art. 31, paragraphs s) and t) of the Hydrocarbons Law obliges PetroEcuador, its contractors or associates in exploration and exploitation of hydrocarbons, refining, transportation and marketing, to conduct operations in accordance with the laws and regulations for environmental protection and safety of the country

CONCLUSIONS

The results indicate that it is possible to incorporate solar panels in the buildings and for the external lighting of the Santa Elena Maritime Terminal Pier, applying a gradual approach to the use of photovoltaic technology, since the conditions for such a task exist, that is, the country is rich in renewable resources, the solar radiation indexes are among the highest in the province of Santa Elena and there are personnel available for this purpose.

In connection with the above, Ecuador is involved in a change of energy matrix that aims at energy efficiency, where renewable energies such as photovoltaic, due to their great potential in the territory, can play a leading role.

There is also a legal obligation enshrined primarily in the Constitution of the Republic of Ecuador and other laws, regulations and decrees derived from it, to undertake actions aimed at conservation and environmental protection, this is binding for individuals, private and public institutions such as the Monteverde Maritime Terminal. Thus, it can be said that all that is needed is the will to execute the pertinent actions in favor of environmental and social responsibility.

REFERENCES

Aguirre, J. (2018). Análisis de la Matriz Energética Ecuatoriana y Plan de Desarrollo Energético Sostenible Para la Ciudad de Machala. *Universitat Politécnica de Valencia. Instituto de Ingeniería eléctrica. Valencia, España. Trabajo Fin de Máster. https://riunet.upv.es/bitstream/handle/10251/106306/P070408412_TFM_153049760950310779954007938552 03.pdf?%20sequenc*, pp.100.

Alonso, J., Fernández, A., Jiménez, C., Lecuona, A., Mellado, F., Plaza, J., y otros. (2007). *Energía Solar Fotovoltaica.* Madrid: Colegio Oficial de Ingenieros de Telecomunicación. Grupo NAP. ISBN: 978-84-935049-6-0. pp.122. https://www.coit.es/sites/default/files/informes/pdf/energia_solar_fotovoltaica.pdf.

Araujo, O., & Lizaldes, D. (2015). Análisis de Consumos Energéticos Asociados a la Operación y Navegación de un Puerto Marítimo del Ecuador. *Escuela Politécnica Nacional. Quito, Ecuador. Trabajo de Titulación. https://bibdigital.epn.edu.ec/bitstream/15000/10783/1/CD-6317.pdf*, pp.115.

ARCERNR. (2021). Panorama Eléctrico. *Agencia de Regulación y Control de Energía y Recursos Naturales no Renovables (ARCERNR). Edición 2. https://www.controlrecursosyenergia.gob.ec/wp-content/uploads/downloads/2021/01/2da-Edicion-Panorama.pdf*.

Bitar, S., & Chamas, F. (2017). Estudio de factibilidad para la implementación de sistemas fotovoltaicos como fuente de energía en el sector industrial de Colombia. *Colegio de Estudios Superiores de Administración (CESA). Bogotá. Colombia. Trabajo de Grado Trabajo de*

Grado de Maestría. https://repository.cesa.edu.co/bitstream/handle/10726/1572/MBA2017-00499.pdf?sequence=10&isAllowed=y, pp.117.

C3S. (2021). El estado europeo del clima 2020. *Servicio de Cambio Climático Copernicus (C3S). https://www.ecmwf.int/en/about/media-centre/news/2021/copernicus-climate-change-service-publishes-report-2020* .

CEPAL. (2020). Estrategia Energética Sustentable 2030 de los países del SICA. *Comisión Económica para América Latina y el Caribe (CEPAL), Naciones Unidas, Ciudad de México/Sistema de la Integración Centroamericana (SICA)*, pp.214.

CONELEC & CIE. (2008). Atlas Solar del Ecuador Con Fines de Generación Eléctrica. *Consejo Nacional de Electricidad (CONELEC/ Corporación para la Investigación Energética (CIE). https://biblioteca.olade.org/opac-tmpl/Documentos/cg00041.pdf* , pp.51.

Finol, T., & Nava, H. (2001). *Procesos y Productos en la Investigación Documental.* Maracaibo, Zulia, Venezuela: EDILUZ. ISBN 980-232-388-8. 2a edición. pp.298.

Fridell, E., Winnes, H., & Styhre, L. (2013). Medidas para mejorar la eficiencia energética en el transporte marítimo. *Boletín FAL, 324. doi: http://www.cepal.org/Transporte/noticias/bolfall/0/54070/FAL324-WEB.pdf*.

Grijalva, C., & Vélez, F. (2020). Estudio e Implementación de un Sistema Fotovoltaico Aplicado a Luminarias: Caso de Estudio Unidad Educativa Dr. Francisco Falquez Ampuero. *Universidad Politécnica Salesiana. Trabajo de Titulación. https://dspace.ups.edu.ec/bitstream/123456789/18646/4/UPS-GT002920.pdf*, pp.97.

Grupo de investigación del transporte marítimo de la Fundación de la Universidad de Oviedo. (2008). Consumo de energía y emisiones asociadas al transporte por barco. *Grupo Gestor del Proyecto EnerTrans. Monografías EnerTrans, Núm 15. ISBN: 978-84-89649-48-4. https://www.tecnica-vialibre.es/documentos/Libros/15-EnerTrans_Consumos_barco.pdf*, pp.78.

Guastay, W., & Llanes, E. (2020). El uso de la energía hidráulica para la generación de energía eléctrica Como Estrategia Para el Desarrollo Industrial en el Ecuador . *Universidad, Ciencia y Tecnología Vol. 24, N° 104. DOI: 10.47460/uct.v24i104.363*, pp. 28-35.

Hernández, R., Fernández, C., & Baptista, P. (2006). *Metodología de la Investigación* . México: McGraw Hill. Cuarta Edición.

Hernández, R; Fernández, C; Baptista, P. (2014). *Metodología de la investigación.* México D.F: McGraw-Hill / Interamericana Editores, S.A. 6ª Edición.

Hurtado, J. (2000). *Metodología de la Investigación Holística.* Caracas, Venezuela: Fundación Sypal IBSN 980-6306-06-6. Tercera edición. pp.666.

IEA. (2007). Key World Energy Statistics. *The International Energy Agency (IEA). (https://grist.org/wp-content/uploads/2008/04/key_stats_2007.pdf*, pp.82.

Larrea, M. (2022). El Papel de los Puertos en la Transición Energética . *Cuadernos Orkestra, núm. 02. Instituto Vasco de Competitividad – Fundación Deusto. https://www.orkestra.deusto.es/images/investigacion/publicaciones/informes/cuadernos-orkestra/220022_Papel_puertos_transicion_energetica_ES.pdf*, pp.195.

Liberona, F. (2020). Introducción. En F. H. Böll, F. o. international, & F. Terram, *Atlas del Carbón 2020. Hechos y cifras de un combustible fósil* (pág. pp.60). Santiago, Chile: Editorial (V. i. S. d. P.) Annette Maennel, HBS. Edición Latinoamericana. https://co.boell.org/sites/default/files/2021-04/atlas_del_carbon%20web.pdf.

Looney, B. (2020). Statistical Review of World Energy 2020. *BP España. https://www.bp.com/es_es/spain/home/noticias/notas-de-prensa/statistical-review-of-world-energy-2020.html*.

Malhotra, N., Dávila, J., & Treviño, M. (2004). *Investigación de Mercados* . México: Pearson Educación. pp.137-320.

Mindiola, M., & Recalde, S. (2008). Análisis de metodologías para la evaluación ambiental de la construcción del terminal marítimo en el sector de Monteverde, provincia de Santa Elena. *Escuela Superior Politécnica del Litoral. Guayaquil, Ecuador. Trabajo de Titulación. http://www.dspace.espol.edu.ec/xmlui/bitstream/handle/123456789/6550/D-39038.pdf?sequence=1&isAllowed=y*, pp.180.

Mundo Marítimo. (2019). Terminal Marítimo de Monteverde, Ecuador: recomiendan tomar medidas para su adecuado funcionamiento . *https://www.mundomaritimo.cl/noticias/terminal-maritimo-de-monteverde-ecuador-recomiendan-tomar-medidas-para-su-adecuado-funcionamiento*.

Muñoz, J., Rojas, M., & Barreto, C. (2018). Incentivo a la generación distribuida en el Ecuador. *Ingenius. Revista de Ciencia y Tecnología, núm. 19. https://www.redalyc.org/journal/5055/505554803006/html/*, pp. 60-68.

Navas, W., Durango, R., & Landívar, E. (2022). El potencial de la energía fotovoltaica como fuente de electricidad en Manabí. *Ciencia Digital, 6(1). https://doi.org/10.33262/cienciadigital.v6i1.1956. https://www.cienciadigital.org/revistacienciadigital2/index.php/CienciaDigital/article/view/1956*, pp.91-115.

OIE. (2021). Change in CO2 emissions by fuel, 1990-2021. *Organización Mundial de la Energía (OIE), París https://www.iea.org/data-and-statistics/charts/change-in-co2-emissions-by-fuel-1990-2021* .

Palella, S., & Martins, F. (2012). *Metodología de la Investigación Cuantitativa.* Caracas, Venezuela: Fondo Editorial de la Universidad Pedagógica Experimental Libertador (FEDEUPEL).

Pástor, J. (2019). Breve Resumen de la Ley Orgánica de Eficiencia Energética Aprobada por la Asamblea Nacional del Ecuador. *https://es.linkedin.com/pulse/breve-resumen-de-la-ley-organica-eficiencia-aprobada-por-p%C3%A1stor*.

Poveda, G., Ruiz, K., & González, J. (2017). Desarrollo de Energías Renovables en el Ecuador del Siglo XXI, optimización de recursos económicos y conservación del medio ambiente. *Observatorio Economía Latinoamericana. ISSN: 1696-8352 [En línea] http://www.eumed.net/cursecon/ecolat/ec/2017/energias-renovables-ecuador.html*.

Prado, B. (2020). Análisis Técnico-Económico de una Instalación Fotovoltaica en Consumidores Residenciales en Áreas Rurales Aisladas. *Universidad Politécnica Salesiana Sede Quito, Ecuador. Trabajo del Titulación.https://dspace.ups.edu.ec/bitstream/123456789/19154/1/UPS%20-%20TTS103.pdf*, pp.118.

Velasco, G., & Cabrera, E. (2010). Generación solar fotovoltaica dentro del esquema de generación distribuida para la provincia de Imbabura. *Escuela Politécnica del Ejército (ESPE), Quito. Ecuador. Maestría en Energías Renovables. https://bibdigital.epn.edu.ec/bitstream/15000/9350/1/P72.pdf*, pp.1-7.

Wilmsmeier, G. (2014). Preocupación por eficiencia energética en la industria portuaria. *Mundo Maritimo. https://www.mundomaritimo.cl/noticias/preocupacion-por-eficiencia-energetica-en-la-industria-portuaria*.

Contribution of each author to the manuscript:

	% of contribution of each author		
Task	**A1**	**A2**	**A3**
A. theoretical and conceptual foundations and problematization:	30%	30%	30%
B. data research and statistical analysis:	30%	30%	30%
C. elaboration of figures and tables:	30%	30%	30%
D. drafting, reviewing and writing of the text:	30%	30%	30%
E. selection of bibliographical references	30%	30%	30%
F. Other (please indicate)	30%	30%	30%

Indication of conflict of interest:

There is no conflict of interest

Source of funding

There is no source of funding

Acknowledgments

There is no acknowledgments