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Microgrids Views from a Geographic Information System

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Abstract

Currently, Ecuador advocates a change in the energy matrix, academic centers should develop a strategy that allows them to short and medium-term training specialists give technical responses to this proposal it must create the conditions in college so that future generations be able to link the processes of investment in energy with the territorial space. The Technical University of Manabí (UTM) has proposed a research project funded by the National Secretary of Planning and Development of Ecuador (Senplades), aimed at boosting sustainable energy solutions that are based on the technical philosophy of microgrids with the use of renewable energy sources (RES). In this paper the spatial information related to solar energy potential of the province of Manabí, Ecuador's, managed by a geographic information system (GIS) as an integration tool that provides information on objectives that interact with microgrids shown, also the importance of its use as a management tool projects related to the use of RES and instrumentation aimed at ensuring innovative solutions to support the change of energy matrix from a territorial perspective is exposed.

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1. Introduction

The oil crisis and pollution caused in power generation based on the use of fossil fuels as well for the transmission, distribution, and supply of electricity, has led to the current energy development approach of clean technologies. This initiative has prompted the introduction of technologies that reduce oil consumption in the generation, reducing the economic costs of electricity production and the reduction of environmental impacts.

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On the other hand, the introduction of clean technologies has been increasing from the concept that RES are distributed in the territorial space, so it can be exploited in a decentralized manner and thus generate electricity close to consumption centers. By doing that, transmission and distribution losses will reduce and also expenses for technological investment. With this generation schemes are less necessary transformers and the construction of new power lines.

The previous analysis allows to define that this issue becomes a task not only for engineers but a transdisciplinary problem where different sciences are involved for example, the need for studies of renewable potential (solar, wind, biomass, hydraulic, geothermal, tidal and others), require the assistance of geographical sciences, land management, meteorology, physics, astronomy and other sciences which must be linked to electrical engineering. Each type of potential in most cases is studied by people with different profiles, where technical working group project, can play a decisive role.

The introduction of renewable technologies in any of the modes and forms that application requires the conduct of space studies to determine the requirements such as the availability and quality of energy potentials; availability of territorial space to undertake investments; environmental risks; risks of natural disasters; interest provided in the prospects of future development of the territories; among others. In this case, the technologies relating to geographic information systems (GIS) are very important tools for viable and transparent analyze necessary to perform.

As background one can assert that it is a curiosity the fact that the countries occupying the leadership in the implementation of technologies that use solar energy to generate electricity correspond to countries whose geographical location receive a lower level of radiation Solar than Ecuador. One example can be cited some countries during 2014 continued to drive the photovoltaic initiatives, as in the case of Germany that installed 3,300 MWp, Italy with 1,400 MWp and Britain with 1000 MWp [1].

Most of the photovoltaic investments in 2014, have been based on the concepts of the next generation consumers, where you can experience a decrease in transmission losses and distribution, reducing environmental impacts not only emissions but also by land use, as well as the adjustment in the use of technologies.

Currently, Germany ranks as one of the world leaders in installed PV power and the fact that disaggregating data on solar and installed wind power, 50% of solar energy is owned by individuals and farms listed as producers highlights independent, while 54% of wind power is in the hands of the same groups. The effect of this policy can be noticed when analyzed in Germany there are about 17 GW of solar PV installed, compared with about 3.6 GW in the US listed as one of the leading countries and dominated centralized facilities [2].

In the German model stands decentralization in generating greater relocation and regionalization of economic activity, democratic change in the control of resources and a break in the way electricity is generated over the last century, where the world it becomes smaller the more connected and manageable and therefore somehow larger for the same time.

The GIS, are a set of tools that integrate and link various components (users, hardware, software, processes, etc.), allowing the organization, storage, manipulation, analysis and modeling of large amounts of data from the real world and are linked to a spatial reference, facilitating the incorporation of social, cultural, economic and environmental aspects that can lead to making decisions more effectively.

In some cases to make investments, they are often used large areas of land that are disabled for other uses and the use of GIS can facilitate a deeper and multilateral evaluation of land use, according to economize and optimize the use of space. This is a key element for the evaluations concerning the introduction of photovoltaic technology, for photovoltaic modules can be installed either at ground level or on surfaces and roof of buildings and houses.

Today GIS are used in the energy field for different uses, for example in studies of spatial planning renewable potential in the island of Cuba [3], where a study of renewable potential was carried out and the areas were determined conditions for investment in grid-connected systems, determining the efficiency in the use of power lines for each type of energy, this study allowed an analysis for isolated system with microgrids in solar, wind, biomass and water systems.

Another study conducted with the help of GIS as an analysis tool, is linked with the integrated planning of electrification [4], where it carried out an alternative sensitivity analysis, which has been studied the influence of five parameters of the cost of power generation of each technology for the entire territory: for example in wind generation, the electricity tariff, the price of diesel, the contracted power and energy demand per household (linked latter two).

As have been studied in an integrated manner existing renewable potential in some areas, it has been able to study the feasibility of its introduction as close as possible to the centers of consumption, so that in the same place can be exploited more than one of them independently or by making hybrid systems to meet demand, with a suitably economical and environmentally sustainable result.

One of the features offered by SIG, is their databases are geo-referenced, allowing to make a real-time analysis of what happens physically in the systems, including the situation of the generation and consumption of energy. This allows users to make quick and effective consultations regarding the reliability of the information.

The aim of this work is to demonstrate the relationship between microgrids and GIS, where highlights the usefulness of these tools for articulating based RES by way of distributed generation systems, incorporating independent producers energy, say individuals or farms.

2. Materials and Methods

Published was used for cartographic information on the website of the regional scale of 1: 250,000 in January 2013 version. Basic layers of Geographic Information IGM free access. (UTF-8, these layers have assisted in the course of the analysis concerning the areas which are close to the people and having a renewable potential that can be exploited [5]. As well used further information published on the website of the NASA [6] and studies that have used this information to study the potential of renewable sources was used, taking into account that satellite data can be unreliable, if not integrated analysis of climatological parameters of the sites where the study is conducted. This analysis does not work with data measured on the ground, only the satellite data, which allows acquiring a good approximate view on energy interpretation of measurements of solar radiation and wind, causing the performance of calculations and study for the implementation of investments in isolated and connected to the network microgrids.

3. Results and Discussions

From the selected information incident radiation was selected on a horizontal surface of Ecuador. It allows defining that the global solar radiation has no difference with the inclined plane, given the geographical location of the territory latitudinal studied.

average values were taken over a period of 22 years (July 1983 - June 2005). Each monthly averaged value is evaluated as the average of the values obtained every three hours and averaging a daily and taken to the monthly average value.

With these values was obtained map average solar potential annual report to the province of Manabi in kWh/ m^2day, shown in Figure 1, where one can observe that the territorial behavior is not uniform and varies throughout the geographical area of the province, it is appropriate to determine, until measures the areas of greatest radiation found in urban centers with the highest concentration of electricity consumption, mainly during daylight hours, when solar radiation is available. The results of the analysis can provide the certainty, as far as is feasible to introduce photovoltaic technology, mainly the systems connected to the network and network power can be saved by providing photovoltaic generation.

In order to support the change of energy matrix which today has set a policy to Ecuador, this information is a potential reserve analysis to facilitate the realization of diversifying will of the national energy base, incorporating other generation sources such as the solar.

When handling the information with GIS it was found that the province of Manabi throughout its territory, has a solar potential that can be harnessed to generate electricity, both grid-connected systems such as autonomous systems rural electrification, water pumping, and photovoltaic lighting. The strongest annual average solar radiation is concentrated in the center, the south, and northwest of the province, with values between 4.7 kWh/m^2 day and 5.2 kWh/m^2 day.

The solar energy performance potential of the province of Manabi allows you to define, that the use of solar radiation through the application of photovoltaic technology in the way of microgrids, can represent a specific productivity MWh annual average between 1.11 and 1.44 MWh. Calculations for specific productivity were performed using equation 1.

$$PE = PS * Ac * \square c * \square s * dAs$$

Where:
PE → Specific Productivity (kWh/kWp)
PS → Solar Potential annual average. (kWh/m^{2}day)
Ac → Area capture of solar radiation by the FV (6,4m^2/kWp) modules
ηc → Efficiency of uptake of cells of primary energy from the Sun = (14%)
ηs- average working efficiency of the photovoltaic system in the life cycle = (85%)
DAS = days of the solar year (362 days)

The specific productivity is the indicator that identifies the amount of energy that can be generated as an annual average, per kWp of installed photovoltaic technology, starting from a given solar potential.

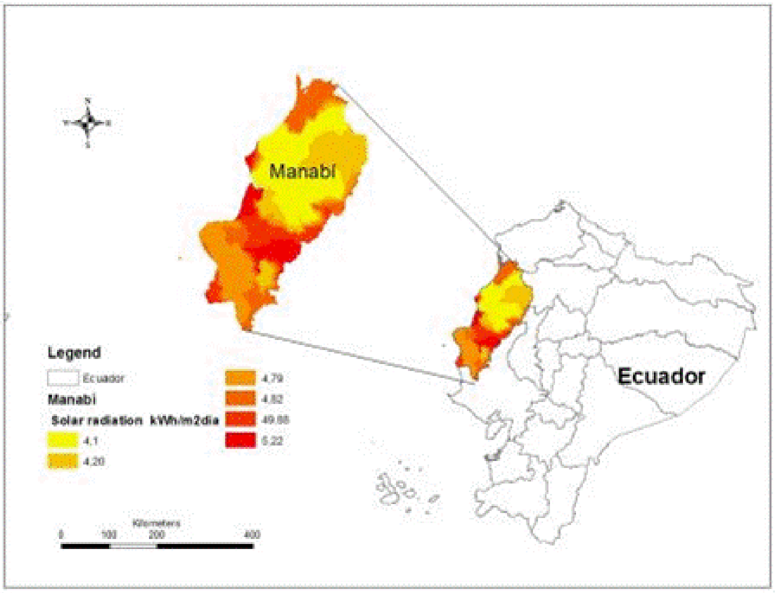

Figure 1. Map of annual average solar radiation in the province of Manabí

The results shown above allow define the conditions of the solar potential in the whole province, encourages the introduction of photovoltaic technologies in a distributed generation mode, using the technical format of microgrids.

At the same time, it can be adopted if we consider the terminal position of the province of Manabí within the radial power system of the country, energy losses by transmission, distribution, and supply of energy can be greater than 30%. Then we can estimate that for every 1 kWh consumed in the province, at least 1.3 kWh are generated which allows to assert that for every 1MWp of installed photovoltaic in microgrids mode could be avoided annually network consumption between 1,44 GWh in areas where solar potential has the lowest effects and 1.87 GWh in places where solar radiation and solar potential has the highest incidence This is approximately equal to saving 164-213 kW of installed power into thermal energy.

Defining an index of average fuel consumption for thermal generation, equivalent to 0.25 ton/MWh, you can calculate the approximate volume of oil avoided annually by the photovoltaic generation of 1 MWp installed mode microgrids, which could be between 359 and 468 ton. Also, if it is considered an index of average CO_2 emissions of 0.9 ton/MWh generated with heat, it could be estimated that emissions can be reduced between 1293 and 1683 ton of CO_2.

The results of measurements of the average annual solar potential (PS), has seven values, which corresponds to a specific productivity (PE) each. Table 1 shows the results of simulations based on the assumption achieve changes in the conditions of the province of Manabí 1 MWp photovoltaic (PV) technology mode microgrids. It showed estimates are as follows: Photovoltaic energy that can be generated (EFvg); Total energy of avoided network, which includes 30% estimated losses in the province of Manabí (Ere); and avoiding oil (Pe); and CO_2 emissions can be reduced (CO_2r).

Table 1
Results of simulations with a PV power installed capacity of 1 MWp mode microgrids in the province of Manabí

PS (kWh/m^2 day)	PE (kWh/kWp year)	EFvg (MWh)	Ere (MWh)	Pe (ton)	CO_2r (ton)
4,000	1103	1,1	1,4	358	1290
4,100	1130	1,1	1,5	367	1323
4,200	1158	1,2	1,5	376	1355
4,700	1296	1,3	1,7	421	1516
4,800	1323	1,3	1,7	430	1548
4,900	1351	1,4	1,8	439	1581
5,200	1434	1,4	1,9	466	1677

Following a similar methodology could perform spatial representation and determination of energy and environmental calculations for other renewable energy sources.

Based on the methodology and development of calculations, you can develop and introduce the system of algorithms that form part of the GIS. In this way with just one point above the clip we wish to study, we can get the information you want.

The province of Manabí is one of that larger area of coast is in the country with large populations distributed throughout the coast, along with tourist facilities, which could increase self-generation as a diversifying share of renewable sources, including which include the photovoltaic solar and wind, given the potential of these in those areas.

Among the types of houses built on the coast abound and where low-cost and power lines begin to impact. GIS allows you to manage the territory so that they can link different factors to be attractive in the region, take advantage of the sun to enjoy the beach and also to generate energy. Figure 2 shows on the left a picture of the beach and San Jacinto, Crucita right, both in tourist and residential areas. In the enlarged image shown at the bottom, you can see the influence of the power line, as an element of visual intrusion into space.

Figure 2. Crucita and San Jacinto Beach the Manabí coast

Manabí enjoys a very suitable solar potential and there are some areas with wind potential that could be tapped with small and medium-grid installations. These are simple, easy to handle, and with facilities that are currently decreasing which makes them very competitive microgrids, particularly well-suited for insertion in the tourism environment.

Figure 3 shows the map of the solar potential of the province of Manabí with the location of human concentrations and higher population density including one kilometer from the coastline. It can be seen that in most cases, human concentrations are located in areas where the impact of the highest levels of solar radiation which coincides with the areas that could offer the best results in terms of photovoltaic generation as a microgrid.

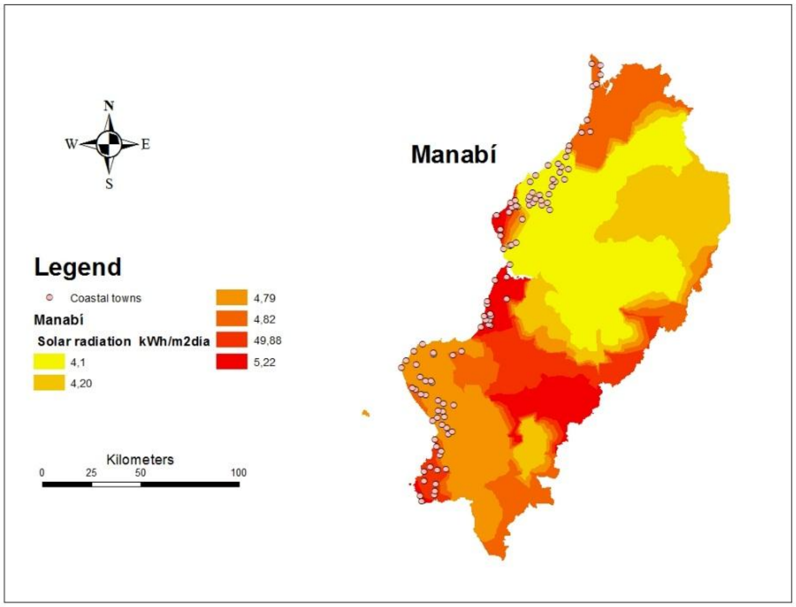

Figure 3. Populations 1 km from the beach and solar potential

The GIS allows performing these analyses and can also integrate different studies that enhance the application, for example, calculate pollution due to sea spray and how it would affect the technologies used, considering various climatological parameters.

The examples shown from the study of solar potential provides the basic ideas of forms and methodology that can be applied to the study and management of other renewable energy sources. A performed integrated analysis and a comparison for each selected site must be done in order to select the appropriate technology to introduce according to their characteristics, thereby providing elements of any site and determine the parameters which could affect the achievement sustainability, and the diversification of the energy matrix from the comprehensive analysis of the territories in this case the province Manabí.

4. Conclusion

The close relationship between renewable energy sources (in this case solar energy) and territorial space was successfully demonstrated so that this relationship is proportionally transitive to microgrids and GIS. The usefulness of this tool to facilitate and enable integrated studies of RES penetration, especially in the mode of distributed generation has also been demonstrated.

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Statement of authorship
The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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