

ENERGY EFFICIENCY AND SUSTAINABILITY: ANALYSIS OF GENERATION, ENERGY QUALITY, AND ENVIRONMENTAL MANAGEMENT INDICATORS OF THE UNIEVANGÉLICA PHOTOVOLTAIC PLANT IN ANÁPOLIS, GOIÁS (2019-2022)

Márcio José Dias¹

Sandro Dutra e Silva²

Ricardo Henrique Fonseca Alves³

Summary:

Electricity is one of the most widely used forms of energy in the world, primarily generated by harnessing the energy potential of water in hydroelectric plants. However, it can also be generated in wind farms, thermal power plants, solar plants, nuclear plants, among others. Therefore, in Brazil, the generation of electricity through the photovoltaic process is extremely promising – solar generation in a clean, renewed, and sustainable way, as the country has an extensive territorial area with high levels of solar irradiation. In this sense, there are several research works involving the financial and technical reasons for the installation of photovoltaic plants. However, little is known or explored about the environmental, scientific, social, and architectural impacts/benefits, as well as the vision for studies and research on the installations of Photovoltaic Plants. Therefore, this work aims to analyze the energy efficiency and sustainability patterns of the UniEVANGÉLICA Photovoltaic Plant, and correlate them with the environmental benefits achieved through the generation of clean, renewable, and sustainable electricity. To this end, the following methodologies are being used: Theoretical Research – in order to understand the State of the Art and/or Scientometrics, the platforms Web Of Science, Science Direct, Scielo, Scopus, ACM, and others are being used; Practical Research - for conducting technical studies on the transmission of generated energy, quality of the generated energy, and efficiency of the system of this electric power generation system through the photovoltaic process, the Energy Efficiency Laboratory of UniEVANGÉLICA (LEEFoto) is being used. As expected results, it aims to generate knowledge in the area of management and energy efficiency of photovoltaic plants as well as validations of methodologies to assist in decision-making for the use of clean and sustainable electricity generation, with an emphasis on the generation indicators of the UniEVANGÉLICA Photovoltaic Plant and environmental indicators (solar radiation, wind speed, and climate changes) of the municipality of Anápolis-Goiás.

¹M.Sc, Evangelical University of Goiás – UniEVANGÉLICA; prof.eng.marciodias@gmail.com (Graduate Student in the Postgraduate Program in Society, Technology, and Environment - PPG STMA - UniEVANGÉLICA)

²D.Sc, Evangelical University of Goiás – UniEVANGÉLICA; sandrodutra@unievangelica.edu.br (Supervising Professor, PPG-STMA)

³D.Sc, Evangelical University of Goiás – UniEVANGÉLICA; ricardo.alves@unievangelica.edu.br (Co-Supervisor Professor, Bachelor's Degree in Electrical Engineering)

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Introduction

Electric energy is of fundamental importance for the development of current societies, so it can be converted to generate light, heat, sound, and mechanical force. Electric energy is one of the most widely used forms of energy in the world, being generated mainly in hydroelectric plants, using the energy potential of water. However, it can also be generated in wind, thermoelectric, solar, nuclear plants, among others (Energy Research Company, 2020).

The new habits of modern society, as well as the growth of industrialization, have led to a worldwide increase in electricity consumption. Therefore, alternative sources of its generation, especially through renewable processes, present themselves as a solution to meet this demand.

In this sense, the generation of electric energy through solar sources using photovoltaic technology has proven to be quite promising in the national energy market. Brazil has an extensive territorial area with high levels of solar irradiation, which makes the implementation of photovoltaic energy generation systems feasible. The Ten-Year Energy Expansion Plan (PDE) estimates that in our country, the installed capacity of solar generation will reach 8,300MW in 2024, with 7,000MW from centralized generation and 1,300MW from distributed generation. (Portal Solar, 2019; REDISKE; RIGO; BURIN; ROSA et al., 2020).

MENDONÇA; FRANCISCO; SOUZA; MINATO et al. (2020) concluded in their studies that the main reasons for the demand and installation of solar panels are long-term savings and independence from the electrical grid. In this sense, there are several research works involving the financial and technical reasons for the installation of small or large-scale photovoltaic power plants. However, SOUZA and OLIVEIRA (2019) state that little is known or explored about the environmental, scientific, social, and architectural impacts/benefits, as well as the perspective of studies and research on the installations of Photovoltaic Plants.

However, the Evangelical University of Goiás – UniEVANGÉLICA, in October 2019, inaugurated its Photovoltaic Plant which, in addition to financial sustainability goals, aimed to promote and expand: science, technology, and innovation as well as to

support the preservation of the environment through the generation of its own clean and sustainable electricity. Thus, UniEVANGÉLICA, in partnership with ENEL-Goiás, built the "Largest Solar Parking Lot in the Country" at that time. The Urban Photovoltaic Plant of UniEVANGÉLICA, Figure 1, installed in the institution's parking lot, with space for 464 cars, has an installed capacity of 971,500 KWp and is currently generating an average of (4.112 MW - day; 123.380 MW - month; 1.480 GW - year) in a clean and sustainable manner, being sufficient to meet 60% to 80% of its energy demand, or supply approximately 1000 low-income houses (UniEVANGÉLICA, 2019).

Figure 1. Photovoltaic Plant of UniEVANGÉLICA



Source: UniEVANGÉLICA, 2019

In this project, approximately R\$ 8 million were invested, and thus the Photovoltaic Plant of UniEVANGÉLICA contributes to various initiatives to fulfill its Mission, Vision, Values, and Institutional Policy.

Thus, this work aims to analyze the energy efficiency and sustainability patterns of the UniEVANGÉLICA Photovoltaic Plant, and correlate them with the environmental benefits achieved through the generation of clean, renewable, and sustainable electricity. Thus, this study corroborates with the institutional purposes mentioned above and is part of the author's Research Project – Márcio José Dias, as a partial requirement for obtaining the title of Doctor in Environmental Sciences from the Graduate Program in Society, Technology, and Environment (PPG STMA) at UniEVANGÉLICA.

Materials and Methods

This work is being developed based on the studies of electricity generation from the UniEVANGÉLICA Photovoltaic Plant, using solar irradiation and climatological data from the municipality of Anápolis - Goiás (the location of the plant under study).

The Photovoltaic Plant of UniEVANGÉLICA was installed in the Institution's parking lot in October 2019 and has a generation capacity of 971,500 KWp, occupying an approximate area of 5,630 m², and features 2,900 photovoltaic panels.

The municipality of Anápolis is geographically located at an altitude of 1017 m, latitude 16°17'39.1" and longitude 48°56'36.1", with an average solar irradiation of 5.21 kWh/m² and wind speeds of up to 5.7 m/s.

For the development of theoretical research, in order to understand the State of the Art and/or Scientometrics, research is being conducted on platforms such as Web Of Science, Science Direct, Scielo, Scopus, ACM, and others.

Practical research involving management data of photovoltaic generation from the UniEVANGÉLICA Photovoltaic Plant is being conducted at the Photovoltaic Energy Efficiency Laboratory (LEEFoto) of UniEVANGÉLICA, located in the institution's solar parking lot. Also, at LEEFoto, technical studies are being conducted on the transmission of generated energy, the quality of the generated energy, and the efficiency of the system of this electric power generation system through the photovoltaic process.

The materialization of this study – technical-scientific publications (technical notes, articles published in journals, conference communications, among others), as previously mentioned, will be part of the composition of the doctoral thesis of the author – Márcio José Dias for obtaining the title of Doctor of Environmental Sciences from the Graduate Program in Society, Technology, and Environment (PPG STMA) at UniEVANGÉLICA.

Results

The present work will provide knowledge generation in the area of management and energy efficiency of photovoltaic plants as well as validations of methodologies to assist in decision-making for the use of clean and sustainable electricity generation, with an emphasis on the generation indicators of the UniEVANGÉLICA Photovoltaic Plant (2019-2022), and environmental indicators (solar radiation, wind speed, and climate change) of the municipality of Anápolis-Goiás.

Furthermore, generating knowledge about Artificial Intelligence (AI) through programming techniques and machine intelligence, in order to enhance statistical data

and achieve more consistent results for predicting simulated data based on real data. Thus, disseminating knowledge about neural network training for decision-making in energy and environmental management will also be purposes of this research project.

Publication of articles in indexed journals involving the themes and objectives of this Doctoral Thesis.

Conclusion

It is expected to demonstrate and quantify the environmental, scientific, and social impacts/benefits already achieved, as well as those that will be achieved from the electricity generation of the UniEVANGÉLICA photovoltaic plant.

Bibliographic References

Energy Research Company. 2020. Available at: <https://www.epe.gov.br/pt/abcedenergia/formas-de-energia>. Accessed on: January 29, 2022. Accessed on: January 29, 2022.

MENDONÇA, M.; FRANCISCO, T. R.; SOUZA, L. B. d.; MINATO, T. et al. Analysis of Motivation and Satisfaction in the Installation of Photovoltaic Solar Panels Using Fuzzy Cognitive Maps. Technical-Scientific Journal of CREA-PR -, 23rd, p. 21, 2020.

Portal Solar. 2019. Available at: <https://www.portalsolar.com.br/blog-solar/energia-solar/brasil-ganha-primeira-usina-solar-flutuante-no-reservatorio-de-sobradinho-ba>. Accessed on: January 31, 2022.

REDISKE, G.; RIGO, P. D.; BURIN, H. P.; ROSA, C. B. et al., 2020, Fortaleza, Ceará. Level of Importance of Criteria in Decision-Making Regarding the Location of Photovoltaic Plants. 10. Available at: <https://anaiscbens.emnuvens.com.br/cbens/article/view/1020/1020> Accessed on: January 15, 2022.

SOUZA, A. B. d.; OLIVEIRA, A. L. Environmental Benefits of Photovoltaic Energy. Interface Tecnológica Journal, 16, p. 12, 2019.

UniEVANGÉLICA. Anápolis, Goiás, 2019, 2019. Available at: <https://www4.unievangelica.edu.br/noticia/6525-unievangelica-inaugura-maior-estacionamento-solar-do-pais>. Accessed on: February 2, 2022.

UniEVANGÉLICA. Anápolis, Goiás, 2021, 2021. Available at: <https://www4.unievangelica.edu.br/noticia/laboratorio-de-eficiencia-energetica-fotovoltaica>. Accessed on: February 2, 2022.