

ENERGY EFFICIENCY AND SUSTAINABLE DEVELOPMENT: OPERATIONAL PERFORMANCE METRICS OF PHOTOVOLTAIC EQUIPMENT PANELS

Lucas Figueiredo Ribeiro ¹

Sandro Dutra e Silva ²

Introduction

With the advent of postmodernism, renewable energy sources gained more strength. Postmodernism emerged between 1968 and 1972, and now all constructions seek a reason, there is nothing absolute anymore, so there is no longer a need to use only non-renewable sources, as postmodernism brought an idea of deconstruction. Foucault believes that a more viable and sustainable production is not something sedentary, but nomadic, that is, it undergoes changes seeking improvements (HARVEY, 2004).

The new technologies that emerge daily require more and more energy, however, planet Earth is going through a complicated period called global warming, that is, it can no longer support such carbon dioxide emissions and such waste of its resources. The most plausible solution would be to produce energy using fewer natural resources and releasing fewer pollutants into the atmosphere.

Strategies and projects that encourage energy conservation, waste reduction, and the reduction of greenhouse gas emissions are being employed in various countries. Two examples are the United States and the members of the European Union. The United States, during the oil supply crisis in 1970, formulated its first efficiency standards (DIXON, 2010). In the same period, the European Union created legal instruments aimed at reducing energy demand and pollutant emissions (FOUQUET, 2013).

Clean energy is derived from natural resources that are replenished on a larger scale than they are consumed, for example: there is more sunlight entering the planet than mankind will ever be able to use. However, they produce much fewer problems for nature compared to non-renewables, as when fossil fuel is burned to produce energy, it causes a large and dangerous emission of carbon dioxide. Renewables also produce this harmful gas, but at a much lower level, making them useful in the fight against the climate crisis the world is facing.

Until now, the renewable sources are: biomass, wind, hydro, ocean (tidal), geothermal, green hydrogen, and solar (NADARAJAH et al., 2016).

Countries like Brazil, the United States, and the European Union bloc have devised paths to meet this domestic demand. The Ministry of Mines and Energy has composed two long-term projects, called the National Energy Plan – PNE 2030 and 2050. The second aims for a Brazilian energy matrix with over 50% renewable sources. (JANNUZZI, 2005).

¹ Mechanical Engineer, Master's in Society, Technology, and Environment, UniEvangélica, Email: lucfigrib@gmail.com

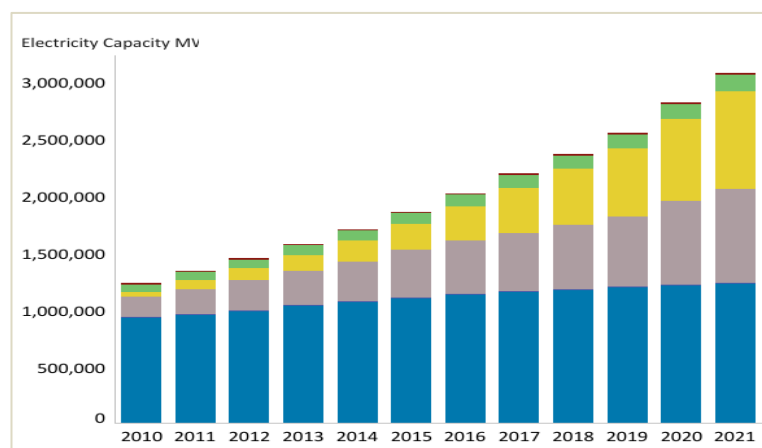
² Pro-Rector of Graduate Studies, Research, Extension, and Action, UniEvangélica, Email: sandrodutra@unievangelica.edu.br

The United States has a clean energy plan. This aims to boost the production of clean energy from wind and solar sources, with the goal of promoting better sustainability for the country. The U.S. Department of Energy is working to promote the efficiency of new energy projects in areas with the goal of expanding the production of solar energy, onshore wind energy, and geothermal energy. The goal for solar aims to increase the generation of solar energy delivered in the country from the current 4% to 40% by 2035 and to 45% by 2050^{3 4}.

The challenges that the European Union (EU) faces in the energy sector include issues such as the increasing dependence on imports and the growing global energy demand. The EU's goal is to achieve the target of 20% energy efficiency by 2020, but a new update extended the deadline to 2030 and set the percentage at 32.5% for the increase of renewable sources in the energy mix of the countries in this bloc^{5 6}.

The focus of this is solar energy, as among the various other renewable energy sources, it is the most promising and freely available energy source. The world's main energy source, oil, besides being a fossil fuel highly harmful to the ozone layer, is limited and expensive, and the other sources are still far from becoming as efficient and economically viable as solar energy has already become. Therefore, the sun is a great "tool" to develop the economic status of emerging countries and to bring dignity to disadvantaged people..

Figure 1. Evolution of renewable sources since the year 2010



According to the table, all renewable sources are in full development and expansion worldwide. Solar energy (yellow) is falling behind only hydroelectric (blue). In 2000, the world produced 1228 MW, in 2021 the world produced 854795 MW, so there was an increase of approximately 69000%.

³Fonte: www.whitehouse.gov/briefing-room/statements-releases/2022/01/12/fact-sheet-biden-harris-administration-races-to-deploy-clean-energy-that-creates-jobs-and-lowers-costs/

⁴Source: <https://canalsolar.com.br/governo-dos-eua-quer-aumentar-a-geracao-de-energia-solar-de-4-para-45-ate-2050/>

⁵Fonte: <https://www.europarl.europa.eu/factsheets/pt/sheet/68/politica-energetica-principios-gerais>

⁶Fonte: <https://eurlex.europa.eu/legalcontent/PT/TXT/?uri=celex:32012L0027> <https://eurlex.europa.eu/legalcontent/PT/TXT/?uri=celex:32012L0027>

China is currently leading the annual production ranking with a capacity of 253.4 GW. In 2020, Brazil ranked ninth among the countries that increased their capacity the most within their territory, with an increase of 3.1 GW in capacity in that year alone.

Taking advantage of government programs, the Evangelical University of Goiás – UniEvangélica, partnered with the company ENEL Brazil. In this project, a parking lot containing 2,900 solar panels was built, generating an annual savings of approximately 2,400 MWh. This solar parking lot supplies 60% of all the energy that Unievangélica demands.

The general objective of this work was to analyze, based on bibliographic and documentary research, the main concepts, definitions, and approaches related to energy efficiency. The studies are based on international and Brazilian projects and public policies on the subject. Thus, based on these studies, they aim to construct ideal scenarios, keywords, and analyses of historical and contemporary contexts related to renewable energy production and its relationship with global issues such as climate change and global warming.

Materials and methods

The methodology used sought to analyze the main ongoing policies on clean energy, based on actions from the United States government and the European Union. In the Brazilian case, the studies were based on the National Energy Program from the Ministry of Mines and Energy, with an emphasis on photovoltaic energy.

Partial Results

Studies have shown that solar energy is identified as one of the alternatives for the production of clean energy. In the United States, the goal is to increase the country's solar energy generation from the current 4% to 40% by 2035 and to 45% by 2050. The "Solar Futures Study" program was released by the United States Department of Energy, in which the project considers that solar energy will play a fundamental role in the decarbonization of the country's power grid. The study shows that, by 2035, solar energy has the potential to supply 40% of the country's electricity. By 2050, solar energy could provide 1,600 GW in a zero-carbon grid, producing more electricity than consumed⁷.

In the European Union, solar energy is the fastest-growing energy source. In 2020, the EU solar market grew by 18 GW and 5.2% of the EU's total electricity production came from solar energy. Solar energy is cheap, clean, modular, and flexible. As part of the "REPowerEU" plan, the commission adopted an EU solar energy strategy in May 2022, which identifies the remaining barriers and challenges in the solar energy sector and describes initiatives to overcome them and accelerate the deployment of solar technologies^{8 9}.

⁷ Source: <https://www.energy.gov/articles/doe-releases-solar-futures-study-providing-blueprint-zero-carbon-grid>

⁸ Fonte: https://energy.ec.europa.eu/topics/renewableenergy/solarenergy_en#:~:text=EU%20Solar%20PV%20Industry%20Allian,almost%20600%20GW%20by%202030

⁹ Fonte: https://energy.ec.europa.eu/topics/renewable-energy_en.

In Brazil, due to its geographical location, the country receives high levels of solar radiation incidence. When compared directly to more developed countries in this area, such as the United States, Germany, and China, this allows for the development of viable solar projects in different regions. Considering only the best available areas, it would be possible to install 307 GWp. A significant expansion of the photovoltaic solar source is expected, and the total centralized installed capacity of solar PV in 2050 could exceed 100 GW. (Ministry of Mines and Energy, 2020).

Conclusion

Consequently, clean energies will be increasingly present in everyday life. In addition to concerns about payback and maintenance costs, another topic is already being addressed: integrating clean energy sources with the environment in which they are installed, making the connection between architecture and efficiency.

Projects and improvements are being studied so that in the coming decades the world's energy matrix will be 50 to 60% renewable, thus aiming in the long term to help planet Earth with its climate crisis and with the future energy crises of future overpopulations.

Acknowledgments

I thank the Goiás State Research Support Foundation – FAPEG, for all the financial support, as it made all the research possible.

Bibliographic References

Administração Biden-Harris corre para implantar energia limpa que cria empregos e reduz custos. Available at: [www.whitehouse.gov.https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/12/fact-sheet-biden-harris-administration-races-to-deploy-clean-energy-that-creates-jobs-and-lowers-costs/](https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/12/fact-sheet-biden-harris-administration-races-to-deploy-clean-energy-that-creates-jobs-and-lowers-costs/). Accessed on July 12, 2022.

Brazil, Ministry of Mines and Energy, Energy Research Company National Energy Plan 2050 / Ministry of Mines and Energy. Energy Research Company. Brasília: MME/EPE, 2020.

Directive 2012/27/EU of the European Parliament. EUR-lex, access to European Union Law. Available at: <https://eur-lex.europa.eu/legal-content/PT/TXT/?uri=celex:32012L0027>. Accessed on August 27, 2022.

DIXON, R. K. et al. Políticas de conservación y eficiencia energética en EE. UU.: Desafíos y oportunidades. Política Energética, v.11, p.6398-408, 2010.

DOE Releases Solar Futures Study Providing the Blueprint for a Zero-Carbon Grid. Energy Gov. Available at: <https://www.energy.gov/articles/doe-releases-solar-futures-study-providing-blueprint-zero-carbon-grid>. Accessed on October 18, 2022.

Enel Goiás installs the largest solar parking lot in Brazil in Anápolis. Enel. Available at: <https://www.enel.com.br/pt-goias/midia/news/d201910-enel-goias-instala-em-anapolis-maior-estacionamento-solar-do-brasil.html>. Accessed on October 14, 2022.

Energy sources. Energy Research Company. Available at: <https://www.epe.gov.br/pt/abcdenergia/fontes-de-energia>. Accessed on August 9, 2022.

FOUQUET, D. Instrumentos de política para la energía renovable – Desde una perspectiva europea. *Energía Renovable*, v.49, p.15-18, 2013.

The United States government wants to increase solar energy generation. Solar Channel. Available at: <https://canalsolar.com.br/governo-dos-eua-quer-aumentar-a-geracao-de-energia-solar-de-4-para-45-ate-2050/>. Accessed on August 27, 2022.

HARVEY, David. *The Condition of Postmodernity*. 13th ed. São Paulo: Edições Loyola, 2004.

JANNUZZI, G. M. Reformas no setor elétrico no Brasil e seus impactos na eficiência energética e nas atividades de pesquisa e desenvolvimento. *Política Energética*, v.3, p.1753-62, 2005.

Nadarajah K. & Divagar V. Solar energy for future world - A review. *Renewable and Sustainable Energy Reviews*, Volume 62, 2016, Pages 1092-1105.

Energy Policy: General Principles. Europarl Europe. Available at: <https://www.europarl.europa.eu/factsheets/pt/sheet/68/politica-energetica-principios-gerais>. Accessed on July 12, 2022.

Energía Renovable. Energy Ec Europe. Available at: https://energy.ec.europa.eu/topics/renewable-energy_en. Accessed on October 18, 2022.

Energía solar. Energy Ec Europa. Available at: https://energy.ec.europa.eu/topics/renewableenergy/solarenergy_en#:~:text=EU%20Solar%20PV%20Industry%20Alliance&text=The%20Commission%20formally%20endorsed%20the,almost%20600%20GW by 2030. Accessed on October 18, 2022.

¿Qué es la energía renovable? Nações Unidas. Available at: <https://www.un.org/en/climatechange/what-is-renewable-energy>. Accessed on August 9, 2022.