RIMA
Revista Interdisciplinar e do Meio Ambiente
Interdisciplinary and Environment Journal
v.6, n.1, 2024, DOI: 10.52664/rima.v6.n1.2024.e229

Estimate of return on investment in solar energy in schools in Sergipe

Estimación de la rentabilidad de la inversión en energía solar en las escuelas de Sergipe

Misael Santana Silva[1] , Renata Souza Vieira[2] , Yasmim Sales Oliveira[3] & Zacarias Caetano Vieira[4]

Abstract: With the growing demand for energy and the environmental challenges associated with the use of fossil fuels and electrical energy in the world, the need to seek energy efficiency to reduce consumption and greenhouse gas emissions is highlighted. In addition, it has reinforced the search for renewable energy sources, emphasizing solar energy, as a sustainable alternative to meet energy demand, especially in Brazil, due to its potential for solar radiation. Public buildings, in particular schools, are identified as significant consumers of electricity, and it is pointed out that the high consumption is not only due to excessive use by consumers, but also to the intensive use of artificial lighting and conditioners of air. As it is an extensive country with high solar irradiation, there is, so, an alternative to reduce environmental impacts. The study area involved 310 schools in Sergipe, and the consumption of electricity was obtained from the website of the Sergipe Department of Education. To simulate the deployment of solar panels, the NEOSOLAR online calculator was used along with the energy tariff, providing information on average investment, and estimated monthly savings. The payback period was calculated using the Simple Payback Method for each school individually. The payback period for all schools was less than 10 years. Thus, it is concluded that the use of solar energy in these establishments proved to be an economically, socially, and environmentally viable practice.
Keywords: *Solar energy; Energy efficiency; Schools.*

Resumen: Con la creciente demanda de energía y los desafíos ambientales asociados con el uso de combustibles fósiles y electricidad en el mundo, se destaca la necesidad de buscar la eficiencia energética para reducir el consumo y las emisiones de gases de efecto invernadero. Además, se hace hincapié en la búsqueda de fuentes de energía renovables, con énfasis en la energía solar, como alternativa sostenible para satisfacer la demanda de energía, especialmente en Brasil, debido a su potencial de radiación solar. Los edificios públicos, en particular las escuelas, se identifican como importantes consumidores de electricidad, y se señala que el alto consumo no se debe sólo al uso excesivo por parte de los consumidores, sino también al uso intensivo de iluminación artificial y acondicionadores de aire. Al tratarse de un país extenso con alta irradiación solar, aporta una alternativa para reducir el impacto ambiental. El área de estudio incluyó 310 escuelas de Sergipe, y el consumo de electricidad se obtuvo de la página web del Departamento de Educación del Estado. Para simular el despliegue de paneles solares, se utilizó la calculadora en línea NEOSOLAR junto con la tarifa energética, proporcionando información sobre la inversión media y el ahorro mensual estimado. El periodo de amortización se calculó utilizando el método de amortización simple para cada escuela individualmente. El periodo de amortización para todos los colegios fue inferior a 10 años. Por lo tanto, se concluye que el uso de la energía solar en estos establecimientos resultó ser una práctica económica, social y ambientalmente viable.
Palabras clave: *Energía solar; Eficiencia energética; Escuelas.*

*Author for correspondence
Received for publication on 2024/04/04; approved on 2023/10/25.
[1] Student, Author, Federal Institute of Sergipe, misa.santana2199@gmail.com, https://orcid.org/0009-0005-6769-4902*;
[2] Student, Coauthor, Federal Institute of Sergipe, renatavieira.se@gmail.com, https://orcid.org/0009-0009-5435-5206;
[3] Student, Coauthor, Federal Institute of Sergipe, yasmin.oliveira067@academico.ifs.edu.br, https://orcid.org/0009-0002-8733-5307;
[4] Professor, Advisor, Federal Institute of Sergipe, zacariascaetano@yahoo.com.br, https://orcid.org/0000-0001-5019-0971.

INTRODUCTION

Due to the need for high energy demand, the world energy matrix is looking for new alternatives for electricity consumption, such as renewable fuels. The high rate of electricity consumption has been degrading the environment due to the pollution that is generated, with the modification of ecosystems and high emissions of greenhouse gases into the atmosphere being notorious (Moura; Motta, 2013). In Brazil, the intense use of hydroelectric plants has led to environmental degradation, such as deforestation in large areas, alterations to rivers and lakes, and loss of biodiversity (Sporl; Ross, 2004).

In this way, energy efficiency is defined as obtaining a service with low energy expenditure. It is not about reducing the service, but about the efficient and rational use of energy and reducing consumption (which consequently leads to lower levels of gas emissions into the atmosphere) (Lamberts, *et al* 2004; *apud* Moura; Motta, 2013). As a result, ways of minimizing environmental impacts caused by man have been gaining ground in society, where the search for new renewable energy sources has been observed, to promote the rational use of natural resources (Limberger; Debora, 2015).

To this end, solar energy, a renewable source of energy from the sun, is considered an excellent alternative energy option to non-renewable sources to meet society's energy demand, since Brazil has a high potential for solar energy production as it benefits from abundant solar radiation for most of the year. In addition, solar energy allows for the expansion of energy availability in places where the implementation of a conventional electricity grid is economically unviable, especially in rural areas (CRESESB, 2006). Brazil's public sector consumes a large portion of the electricity produced in the country. However, it is observed that public buildings themselves have great potential for reducing electricity consumption, as well as for implementing energy efficiency actions (Lage; Lage; Lage, 2015).

Among public buildings, schools stand out for their high electricity consumption. For Antunes (2017), this high energy expenditure in school buildings is not only due to the immoderate consumption of consuming agents but also to the intensive use of artificial lighting and conditioners of air, caused by inadequate architectural standards that disregard climate and energy issues.

In view of the above, the aim of this article is to carry out a simulation of the implementation of photovoltaic systems in public state schools in the state of Sergipe, estimating the investment and the average savings generated, as well as the payback period.

THEORETICAL BACKGROUND

Solar Energy

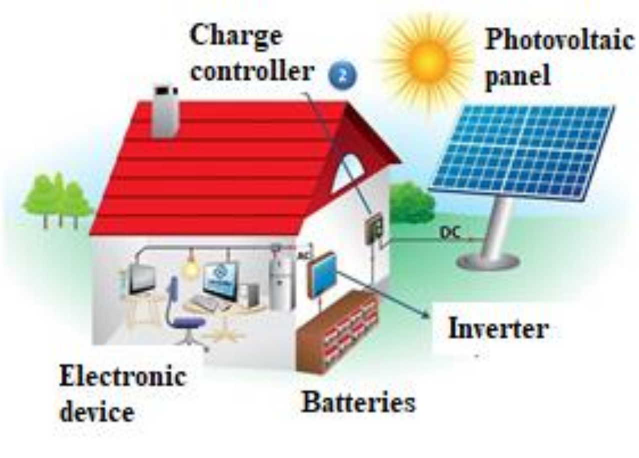
Photovoltaic solar energy is defined as energy generated through the direct conversion of solar radiation into electricity. This is done by means of a device known as a photovoltaic cell, which acts using the principle of the photoelectric or photovoltaic effect (Imhoff, 2007).

Solar Photovoltaic System

A solar energy system, also called a photovoltaic system, is a system in which electrical energy is generated using solar radiation. The photovoltaic system has a few basic components: solar panels (responsible for transforming solar energy into electricity); charge controllers (avoid overcharging or discharging the battery, thus increasing its useful life); inverters (responsible for transforming the direct current of the batteries into alternating current (110V or 220V), as well as synchronizing with the electricity grid) and batteries, in the case of the offgrid system (stores electrical energy so that it can be used later when there is no sun) (Pereira; Oliveira, 2011).

For the system to work (Figure 01), the solar panels are connected in series (string) or in parallel. The electricity generated by the plates passes through inverters which are responsible for converting direct current into alternating current, thus generating conventional electricity. The number and positioning of the plates varies according to the sizing done in the evaluation, that decides the amount of solar energy needed to be generated (Pereira; Oliveira, 2011).

FIGURE 01: Photovoltaic solar energy systems and their components



SOURCE: Neosolar Energia (2023).

National and local electricity potential.

With its vast territory and high solar radiation rates, Brazil has an enormous potential for generating solar energy (Holdermann *et al.*, 2014 *apud* Feitosa, 2023). Characteristics such as the vast territory and high solar irradiation show that Brazil has the potential to substantially increase the generation of photovoltaic solar energy, which could generate tens of thousands of gigawatts of electricity per hour, contributing greatly to reducing the use of fossil fuels and the social and environmental impacts of new hydroelectric plants (Carstens; Cunha, 2019 *apud* Feitosa, 2023). Along the same lines, the state of Sergipe has great potential for generating photovoltaic solar energy.

MATERIALS AND METHODS

Study Area

To carry out this work, 310 schools in the state of Sergipe were used. According to SEED-SE, the state education network is divided into 10 regional directorates of education (Figure 02), in the 75 municipalities of Sergipe, totaling 318 schools. Only 8 schools were not used as they did not have all the information available.

FIGURE 02: Sergipe's Regional Education Directorates

SOURCE: Adapted from SEED-SE (2023).

Average energy consumption in schools

The schools' electrical energy consumption was obtained from the Sergipe State Department of Education, Sport, and Culture (SEED-SE) website, which provides the annual amount paid by each institution to the energy concessionaire. The most up-to-date data available (year of 2019) was considered.

Simulating the implementation of energy in these schools

To simulate the installation of solar panels in public schools in Sergipe, the average investment and monthly savings were calculated using the NEOSOLAR online calculator, in which the necessary information was entered for each school: city, type of building (others were used in this case) and the school's average monthly bill. As a result, the calculator provides the average investment and the estimated average monthly savings.

Calculating the payback period (Simple Payback)

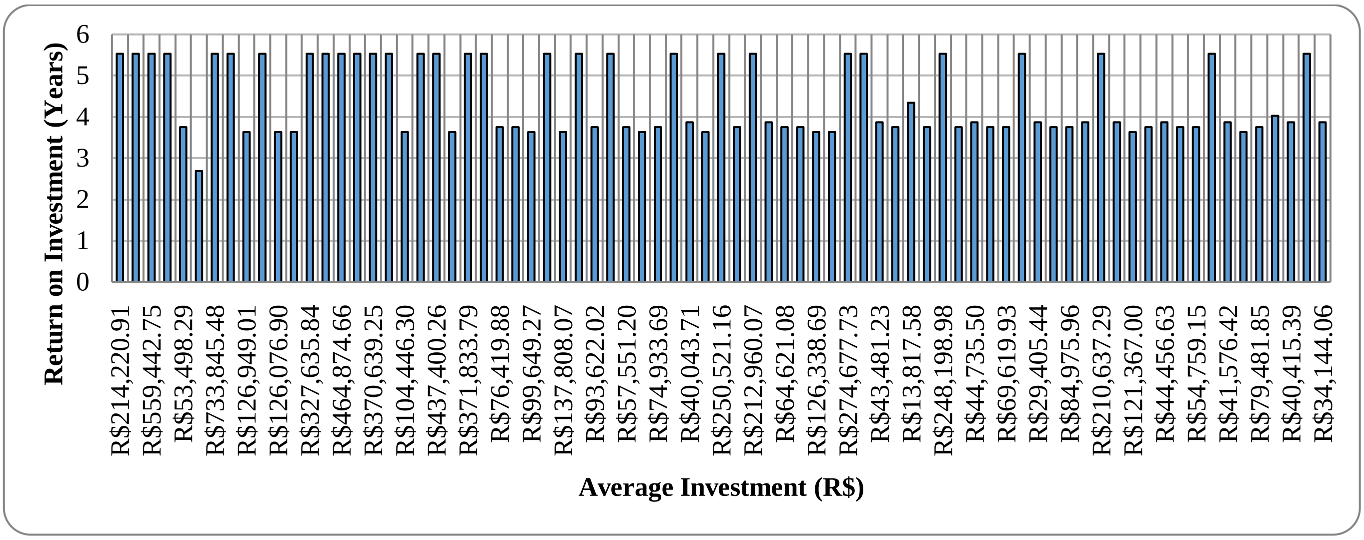
Calculating the payback period involves determining how long it will take to recover the initial investment based on the average investment over the period and the monthly savings resulting from that investment. The formula divides the average investment by the monthly savings and then divides the result by 12 to obtain the number of years needed for the monthly savings to pay back the investment. This calculation is useful for assessing the financial viability of an investment, because allowing you to understand how soon the accumulated financial benefits will equal the amount invested. The shorter the payback period, the faster the investment will be recovered, which is generally considered more favorable (Ismail; Abdullah; Serin, 2013).

Therefore, this work initially consisted of a literature review on the subject. Next, the energy consumption data of Sergipe's state schools in 2019 was consulted. This data was entered into the NEOSOLAR ENERGIA (2023) calculator along with the energy tariff charged by ENERGISA in 2019, to determine the average investment and the estimated average monthly savings. Finally, using the Simple Payback Method, the payback period was calculated for each school. At the end, the results are presented and discussed.

RESULTS AND DISCUSSION

The graph 01, below, shows the payback time and average investment of 77 schools in the Aracaju Education Directorate (DEA).

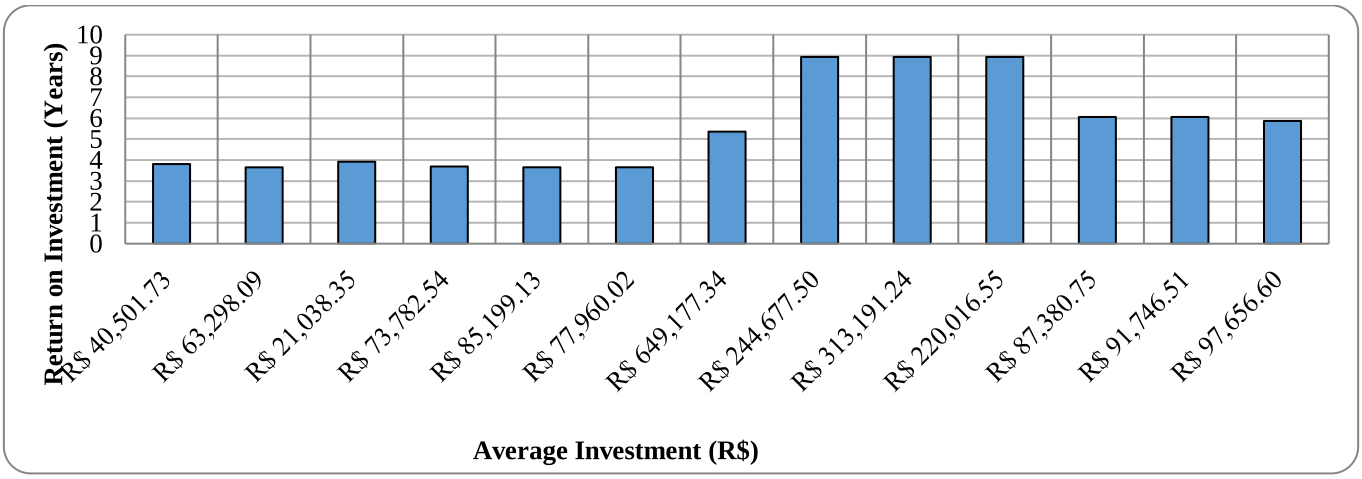
GRAPH 01: Return on investment versus average investment in DEA.



SOURCE: Research data (2023).

In the Aracaju Education Directorate (DEA), the average investment ranged from R$13,817.58 to R$733,845.48, resulting in an average investment of R$183,030.04 for all schools. The payback period ranged from 2.7 years to 5.5 years, resulting in an average of approximately 4.4 years among the schools in this region. Graph 02 shows the payback time and average investment of 28 schools in Regional Directorate 01.

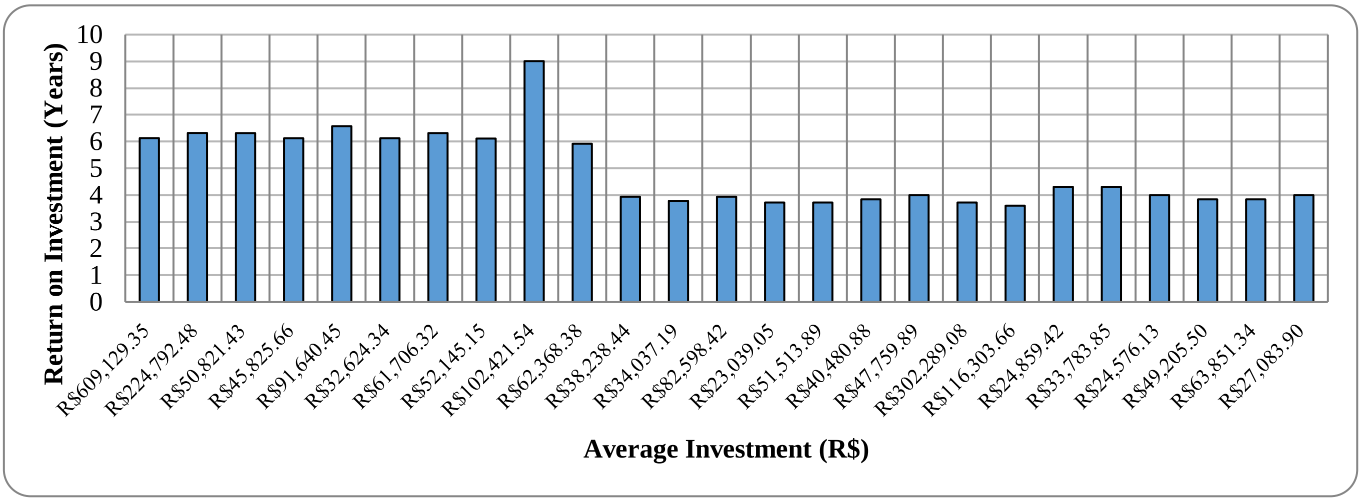
GRAPH 02: Return on investment versus average investment in DRE01.



SOURCE: Research data (2023).

In Regional Education Directorate 01 (DRE01), the average investment ranged from R$3,555.86 to R$668,578.56, resulting in an average investment of R$141,289.37 for all schools. The payback period ranged from 3.7 years to 9.0 years, resulting in an average of approximately 5.6 years among the schools in this region. Graph 03 shows the payback time and average investment of 34 schools in Regional Directorate 02.

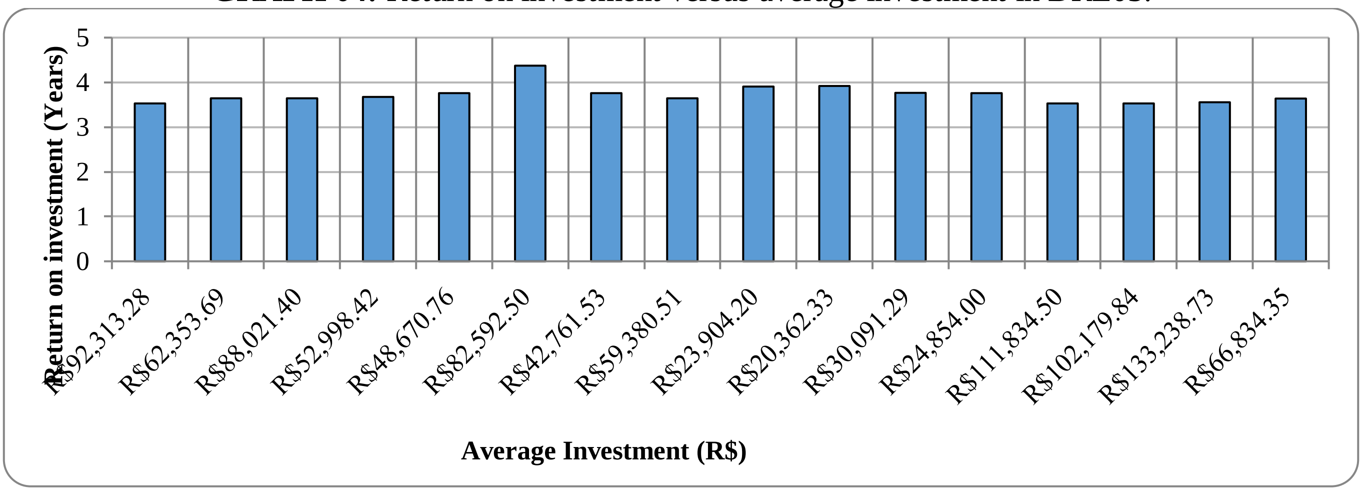
GRAPH 03: Return on investment versus average investment in DRE02.



SOURCE: Research data (2023).

In Regional Education Directorate 02 (DRE02), the average investment ranged from R$13,907.74 to R$609,129.35, resulting in an average investment of R$77,192.07 for all schools. With regard to the payback period, it ranged from 3.7 years to 9.0 years, resulting in an average of approximately 4.9 years among the schools in this region. Graph 04 shows the payback time and average investment of 32 schools in Regional Directorate 03.

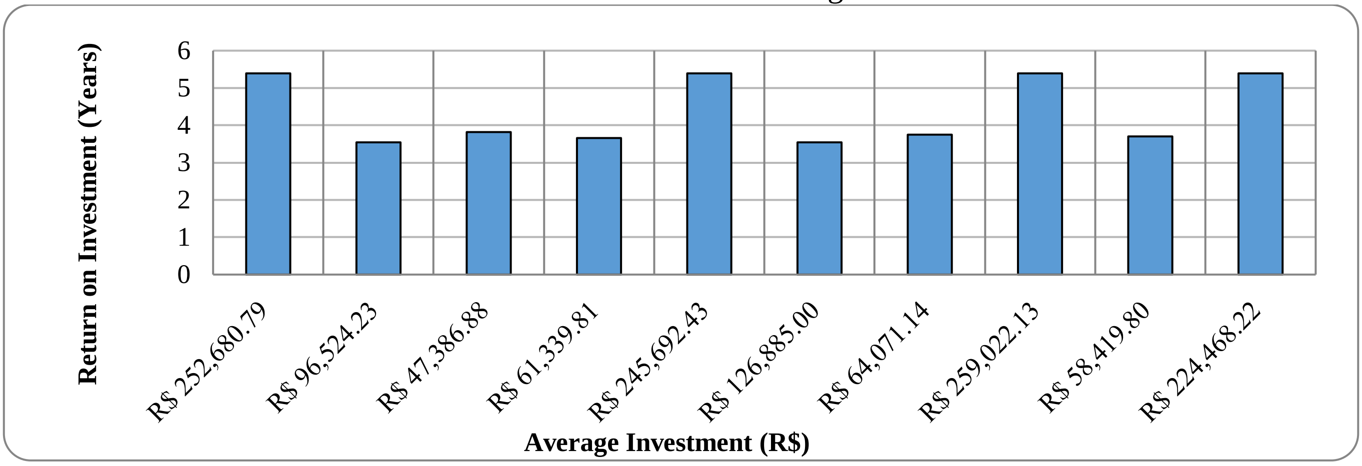
GRAPH 04: Return on investment versus average investment in DRE03.



SOURCE: Research data (2023).

In Regional Education Directorate 03 (DRE03), the average investment ranged from R$20,362.33 to R$515,014.03, resulting in an average investment of R$82,439.37 for all schools. The payback period varied from 3.5 years to 4.4 years, resulting in an average of approximately 3.7 years among the schools in this region. Graph 05 shows the payback time and average investment of 16 schools in Regional Directorate 04.

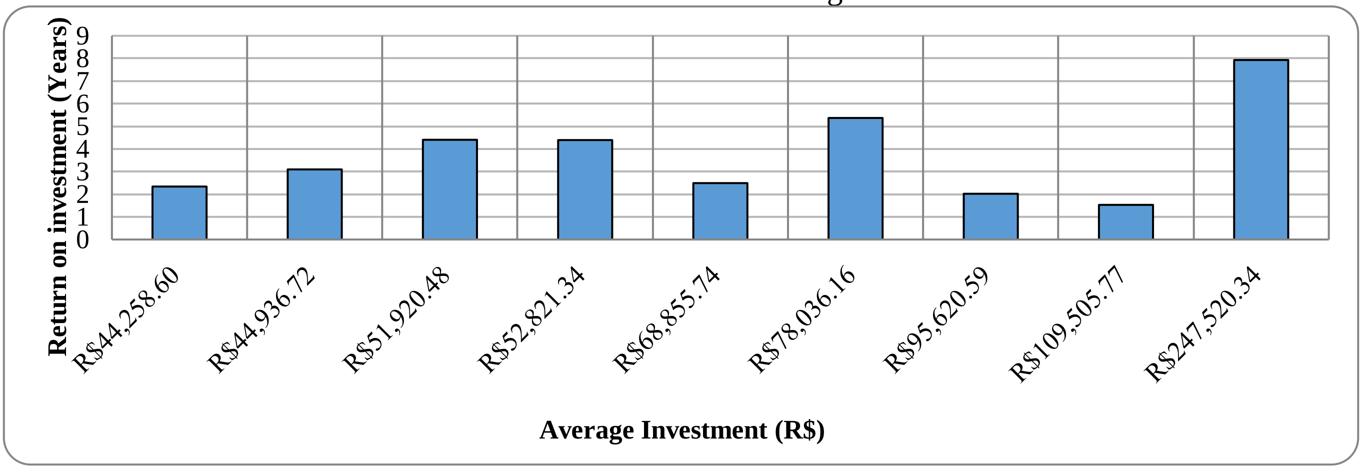
GRAPH 05: Return on investment versus average investment in DRE04.



SOURCE: Research data (2023).

In Regional Education Directorate 04 (DRE04), the average investment ranged from R$19,093.18 to R$259,022.13, resulting in an average investment of R$131,309.13 for all schools. The payback period ranged from 3.5 years to 5.4 years, resulting in an average of approximately 4.4 years among the schools in this region. Graph 06 shows the payback time and average investment of 10 schools in Regional Directorate 05.

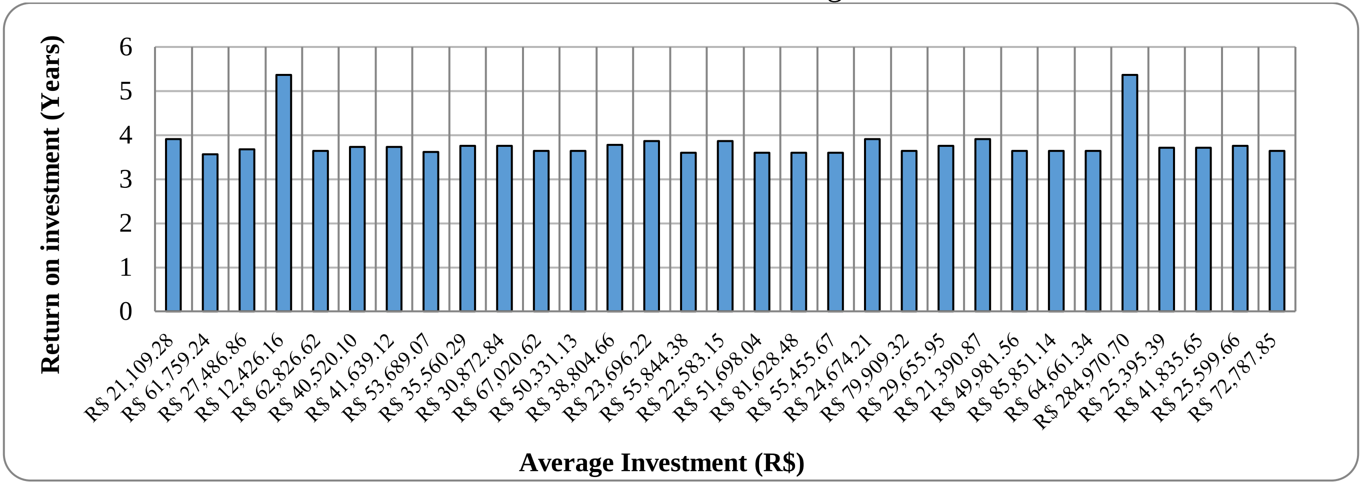
GRAPH 06: Return on investment versus average investment in DRE05.



SOURCE: Research data (2023).

In Regional Education Directorate 05 (DRE05), the average investment ranged from R$44,258.60 to R$382,097.94, resulting in an average investment of R$82,439.37 for all schools. The payback period ranged from 1.5 years to 8.0 years, resulting in an average of approximately 3.7 years among the schools in this region. The Graph 07 shows the payback time and average investment of 31 schools in Regional Directorate 06.

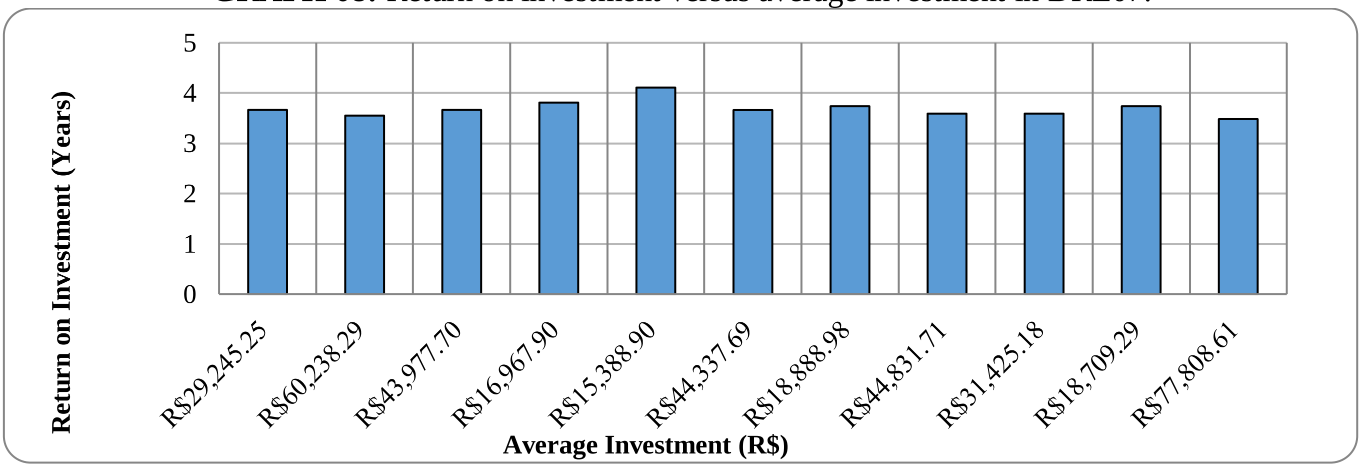
GRAPH 07: Return on investment versus average investment in DRE06.



SOURCE: Research data (2023).

In Regional Education Directorate 06 (DRE06), the average investment ranged from R$12,426.16 to R$284,970.70, resulting in an average investment of R$52,956.95 for all schools. The payback period ranged from 3.6 years to 5.4 years, resulting in an average of approximately 3.9 years among the schools in this region. Graph 08 shows the payback time and average investment of 11 schools in Regional Directorate 07.

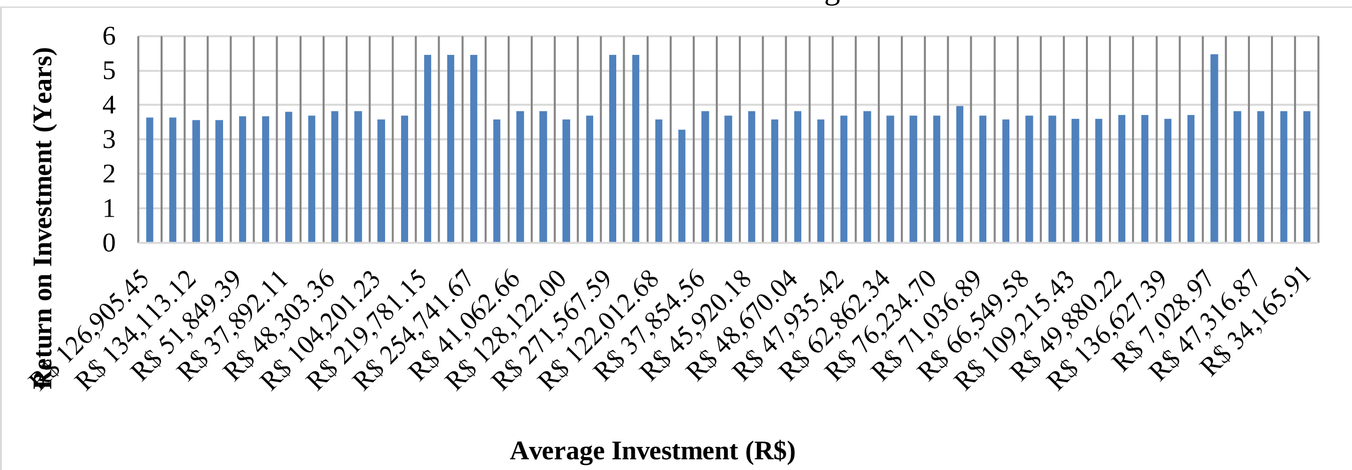
GRAPH 08: Return on investment versus average investment in DRE07.



SOURCE: Research data (2023).

In Regional Education Directorate 07 (DRE07), the average investment ranged from R$15,388.90 to R$60,238.29, resulting in an average investment of R$36,52904 for all schools. The payback period ranged from 3.5 years to 4.1 years, resulting in an average of approximately 3.7 years among the schools in this region. Graph 9 shows the payback time and average investment of 51 schools in Regional Directorate 08.

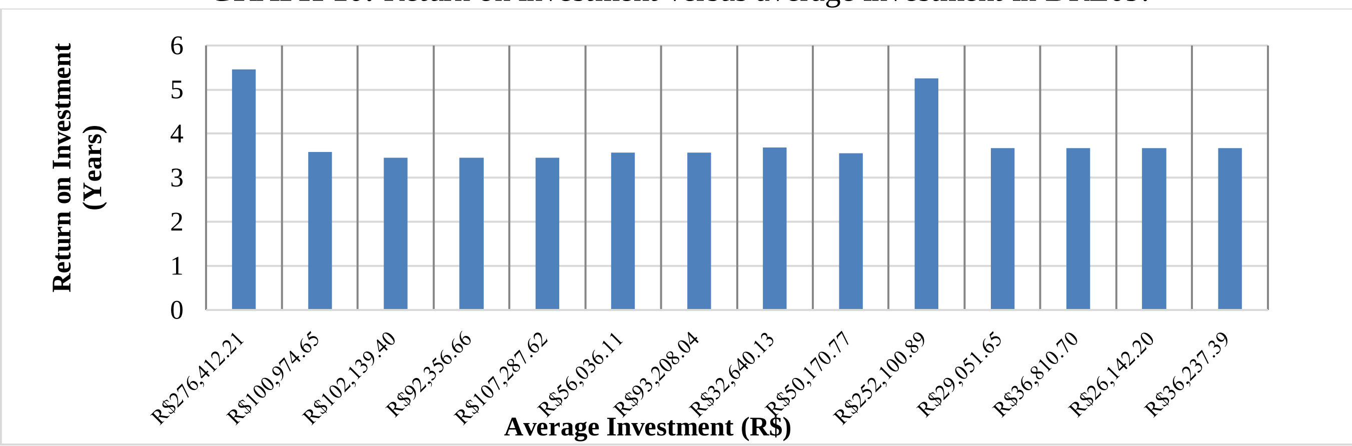
GRAPH 09: Return on investment versus average investment in DRE08.



SOURCE: Research data (2023).

In Regional Education Directorate 08 (DRE08), the average investment ranged from R$ 7,028.97 to R$ 471,642.09, resulting in an average investment of R$ 94,578.34 for all schools. With regard to the payback period, it ranged from 3.3 years to 5.5 years, resulting in an average of approximately 3.8 years among the schools in this region. Graph 10 shows the payback time and average investment of 14 schools in Regional Directorate 09.

GRAPH 10: Return on investment versus average investment in DRE09.



SOURCE: Research data (2023).

In Regional Education Directorate 09 (DRE09), the average investment ranged from R$26,142.20 to R$276,412.21, resulting in an average investment of R$92,254.89 for all schools. The payback period ranged from 3.5 years to 5.5 years, resulting in an average of approximately 3.9 years among the schools in this region.

CONCLUSIONS

Given the growing global demand for energy and the environmental challenges associated with the use of fossil fuels and electricity, the need for energy efficiency to reduce consumption and greenhouse gas emissions is evident. In addition, there is a growing focus on the search for renewable energy sources, emphasizing on solar energy as a sustainable alternative to meet energy demand, especially in Brazil, given its high solar radiation potential. In this context, the aim of this article was to simulate the implementation of photovoltaic systems in schools in the state of Sergipe, estimating the investment and average savings generated, as well as the payback period.

The study also highlights the enormous potential of solar energy in Brazil, given its vast territorial extension and high solar irradiation, which could substantially increase the generation of photovoltaic electricity, reducing dependence on fossil fuels and their associated social and environmental impacts. In addition, the state of Sergipe, in its local context, offers a favorable environment for the development of photovoltaic solar energy systems.

Therefore, with the results presented, it is clear that the use of solar energy in schools is advantageous, as it has a return on investment in the short/medium term, and its use is viable. This viability comes from the fact that schools have a high energy consumption and large areas exposed to the region's climate (coverage area), making it possible to use solar panels. This research serves as a starting point for understanding the potential of adopting renewable energy and energy efficiency measures in the context of public schools, offering valuable insights into how different factors influence waste generation. Ultimately, it supports the promotion of sustainable energy practices and the development of environmentally conscious infrastructures, which is key to tackling the global energy and environmental challenges we face.

REFERENCES

[1] ANTUNES, L. N. Potencial de economia de água potável e energia elétrica em edificações escolares. 2017. 122 f. TCC (Graduação) - Curso de Engenharia Civil, Universidade Federal de Santa Catarina, Florianópolis, 2017.

[2] CONGRESSO BRASILEIRO DE CUSTOS, 2015, Foz do Iguaçu. 2015. Disponível em: http://cbc2015.emnuvens.com.br/anais-do-cbc/. Acesso em: 26 set. 2021.

[3] CRESESB. Tutorial de Energia Solar: princípios e Aplicações. 2006.

[4] FEITOSA, R. O. Geoinformática aplicada na estimativa do potencial fotovoltaico do semiárido sergipano. 2023. 151 f. Tese (Doutorado) - Curso de Pós-Graduação em Desenvolvimento e Meio Ambiente, Universidade Federal de Sergipe, São Cristóvão, 2022.

[5] IMHOFF, J. Desenvolvimento de Conversores Estáticos para Sistemas Fotovoltaicos Autônomos. Dissertação de Mestrado. Escola de Engenharia Elétrica da Universidade Federal de Santa Maria, Santa Maria. 2007. 146 f.

[6] ISMAIL, M. M.; ABDULLAH, A. M.; SERIN, Tapsir Financial assessment of government incentives on broiler production in peninsular Malaysia. In: APPLIED INTERNATIONAL BUSINESS CONFERENCE, 2., Malaysia, 2013. Annals... Malaysia: AIBC, 2013.

[7] LAGE, W. M.; LAGE, M. H. de M.; LAGE, B. L. de M. Aplicação da gestão energética como ferramenta de redução estratégica de custos nas escolas públicas municipais de Belo Horizonte/MG. In: XXII.

[8] LIMBERGER, Débora C. da M. Levantamento de custos para implantação de sistemas sustentáveis em uma edificação residencial. 2015, Monografia (Graduação em Engenharia Civil) – Universidade Tecnológica Federal do Paraná. Toledo, 2015.

[9] MOURA, A.; MOTTA, A. L. T. S. O Fator Energia na Construção Civil.In:IX CONGRESSO NACIONAL DE EXCELÊNCIA EM GESTÃO, 2013.

[10] NEOSOLAR ENERGIA. Simulador solar: Calculadora Solar Fotovoltaica. 2023. Disponível em: https://www.neosolar.com.br/simulador-solar-calculadora-fotovoltaica-resultado. Acesso em: 23 out. 2023.

[11] PEREIRA, F.; OLIVEIRA, M. Curso técnico instalador de energia solar fotovoltaica. Porto: Publindústria, 2011.

[12] SERGIPE. SEED - Secretaria de Estado da Educação, do Esporte e da Cultura. Nossas escolas. Disponível em: https://www.seed.se.gov.br/redeEstadual/escolas-rede.asp. Acesso em: 23 out. 2023.

[13] SPÖRL, C.; ROSS, J. L. S. Análise comparativa da fragilidade ambiental com aplicação de três modelos.In.: GEOUSP-Espaço e Tempo, São Paulo, Nº 15, pp.39-49, 2004.