# FINANCIAL AND ECONOMIC VIABILITY OF TRANSFORMING TO SOLAR ENERGY: CASE STUDY FROM RAJARATA UNIVERSITY OF SRI LANKA

Dissanayaka, H.R.A.S.R.[1] and Rajapakshe, P.S.K.[2]

[1,2]Department of Environmental Management, Faculty of Social Sciences & Humanities, Rajarata University of Sri Lanka, Mihintale, Sri Lanka

*hrasrd95@gmail.com[1], pskr75@gmail.com[2]*

## ABSTRACT

Increasing energy consumption is one of the most critical determinants of climate change. Therefore, energy efficiency strategies and the growing demand for renewable energy sources are significant to minimize the negative impacts of climate change across the globe. This study examines the current electricity consumption of the Faculty of Social Sciences and Humanities (FSSH) of the Rajarata University of Sri Lanka. It explores the potential of using solar power as a renewable energy source to meet the faculty's electricity demand. As the university is located in a dry zone, using solar power as a renewable energy source has enormous potential. This research was based on both primary and secondary data. Primary data were collected from academic and non-academic staff through key person interviews and students through a survey based on a structured questionnaire. Secondary data were collected from electricity bills of the FSSH and available electrical equipment data. Cost-Benefit Analysis (CBA) is mainly employed to examine the financial and economic viability of transforming to solar power to meet the energy requirements of the faculty. This study disclosed that the electricity consumption of the university in general and the FSSH had increased drastically during 2015 - 2018. The study found that electricity consumption creates an external cost of 31856.53 LKR as CO2 emission per year. Results of the financial CBA estimates indicate that installing a solar power system to the FSSH will generate 27,340,401.08 LKR of Net Present Value (NPV) and 1.86 of Cost-Benefit Ratio (CBR), and the Internal Rate of Return (IRR) is 21.63%. After considering the externalities, the results of the economic CBA generate little higher estimates than the financial CBA with 27,677,889.62 LKR of Net Present Value, 1.87 of CBR and 21.81 of IRR. Therefore, it can be concluded that investing in solar energy systems for the FSSH is a financially and economically viable and environmentally sound business.

**Keywords:** ***Climate Change, Electricity Consumption, Energy Efficiency, Solar Power, Cost-Benefit Analysis.***

## 1. INTRODUCTION

Energy is the primary input for almost all economic activities; hence, it has become vital for improving the quality of life (Hossain, 2015; Pehl et al. 2017). People consume energy for various purposes, such as transportation, industrial works, and domestic and commercial activities (NREL, 2017). According to the Global Energy and CO2 Status Report of the International Energy Agency 2019, In 2018, it was reported that global energy demand saw a 2.3% increase, which represented its most rapid growth within the last decade (International Energy Agency, 2019). This rapid energy growth results from population growth, technological improvement, and increasing human needs and wants. People predominantly use non-renewable energy sources such as fossil fuels (coal, petroleum, gas, and nuclear) to meet global energy needs (Oleiwi, et al.,2021).

Renewable and non-renewable energy sources such as coal, oil, natural gas, nuclear, hydropower, solar power, and wind are necessary to generate electricity (International Energy Agency 2023). Electricity generation is the world's largest energy consumer, and primarily, the world uses non-renewable energy sources to generate electricity (International Energy Agency, 2019). The Global Energy and CO2 Status Report for 2018 by the International Energy Agency noted that in 2017, electricity consumption, constituting 19% of total final energy consumption, experienced a growth rate of 3.1%, which marked an increase from the previous year's 1.3%. Additionally, gross electricity production grew by 2.5%, slightly below the 3.1% growth rate observed in 2016 (International Energy Agency, 2018).

Electricity consumption is closely related to the consumption of primary energy sources, such as fossil fuels, which are often used to generate electricity (Hossain, 2015). However, producing electricity from these sources results in significant environmental and health impacts due to the emission of pollutants, such as carbon dioxide, sulfur dioxide, and nitrogen oxides. These pollutants contribute to various environmental problems, such as air pollution, acid rain, and climate change. Also, it creates and traps the sun's heat, contributing to global warming (Ismail, et al., 2015).

Using non-renewable energy sources such as gas and oil has significant environmental impacts that can pose major challenges for countries that rely heavily on these sources for their energy needs (Center for Resource Solutions, 2016). However, high population growth, limited economic development, and increased pollution have resulted in a significant vulnerability to environmental degradation and declining environmental quality in developing countries. This situation can potentially cause substantial harm to human health and well-being and the natural systems on which we depend. Therefore, there is an urgent need to implement policies and strategies that promote sustainable development and protect the environment in these countries (Halder, et al., 2015;Syarafina, et al., 2010).

Sri Lanka primarily uses petroleum and coal as energy sources, and the use of other sources is still at lower levels. Power generation from coal is increasing yearly due to the increasing demand for energy for various purposes throughout the country. Sri Lanka mainly utilizes the national grid for electricity supply, which covers the whole country. The national grid consists of overhead transmission lines interconnecting large-scale power plants. Sri Lanka already achieved 98% of grid connectivity, which is commendable by South Asian standards. According to the Ministry of Power and Renewable Energy, Sri Lanka has 6,647,074 electricity consumers, and the electricity demand rises about 6% annually (Wegapitiya, 2017).The current total power generation is approximately 4,050 MW, fulfilled from 900 MW of coal power, 1,335 MW of oil-burning thermal power, 1,375 MW of hydropower, and 445 MW of nonconventional renewable energy sources like solar, wind, mini-hydro, and biomass (International Energy Agency, 2019). However, despite having a high potential for renewable energy sources, according to the country's geographical position, Sri Lanka still does not supply 100% of the electricity to people and mainly uses non-renewable sources.

Sri Lanka, much like numerous other nations, has grappled with environmental pollution attributed to its reliance on imported non-renewable energy sources. This dependency on fossil fuels has not only resulted in significant environmental ramifications but has also inflicted a considerable economic toll on the country. Currently, approximately 51% of Sri Lanka's energy stems from fossil fuels, exacerbating environmental pollution levels (Ministry of Power and Energy, 2023). However, in recognition of these challenges, Sri Lanka has undertaken a proactive stance, setting a commendable target to augment the contribution of renewable energy to 70% of its energy mix by 2030. This ambitious goal is geared towards mitigating pollution and fostering the adoption of sustainable energy sources across the nation (Ministry of Power and Energy, 2023).

To realize this transformative shift towards sustainability, the Government of Sri Lanka has initiated strategic measures, collaborating with diverse projects aimed at fostering the exchange of expertise in renewable energy technologies (UNDP, 2018). These efforts are instrumental in harnessing innovative solutions and knowledge-sharing platforms to facilitate the transition towards cleaner and more sustainable energy practices within the country.

In pursuit of this goal, the universities have adopted a green concept, which prioritizes creating an eco-friendly environment that promotes sustainable practices. Central to this concept is a focus on energy conservation and efficiency while transforming to renewable energy sources like solar power—this can significantly reduce the university's dependence on non-renewable energy sources. However, it is questionable whether converting to renewable energy like solar power would be a financially and economically viable option.

Selecting Rajarata University to study electricity energy efficiency and the feasibility of transitioning to solar power is justified by its significant energy consumption, potential environmental impact, and the economic incentive to reduce electricity costs. Additionally, the university's status as an educational institution provides an opportunity to set an example for sustainable practices, while government initiatives supporting renewable energy adoption may contribute to the study's relevance and timeliness. The suitability of the university infrastructure for solar power implementation further enhances its potential as a model for clean energy transitions. The study seeks to provide insights into how the university can become more energy-efficient and environmentally sustainable by reviewing the university's current energy consumption patterns, identifying areas for improvement, and exploring alternative energy options. The findings of this study could inform policymakers and practitioners that promoting sustainable energy use in universities can contribute to Sri Lanka's broader goal of achieving energy self-sufficiency. This study will also provide information to private investors seeking investment opportunities in renewable energy like solar power.

## 2. RESEARCH METHODOLOGY

This research primarily examines the electricity consumption pattern and the feasibility of moving to renewable solar energy at the Rajarata University of Sri Lanka. The sample area of this research is selected as the Faculty of Social Sciences and Humanities (FSSH) in the Rajarata University of Sri Lanka, proposing to establish a solar power system on the rooftop of the faculty building. This study employed both primary and secondary data. The choice of a convenient sampling method for surveying 50 undergraduates from the Faculty of Social Sciences and Humanities (FSSH) was driven by practical considerations and accessibility. This approach allowed for efficient data collection within resource constraints, focusing on a subgroup whose perceptions are directly relevant to the study objectives. While acknowledging potential limitations in representativeness, the study aimed to gain insights into the specific demographic of FSSH undergraduates regarding their perceptions of current electricity energy efficiency.

Interviews were held with the academic and non-academic staff to examine their perceptions of electricity consumption and preference for transforming to renewable energy to meet the electricity demand of the faculty. The (sample of the) key persons included the dean of the faculty, department heads of the faculty, and ten non-academic staff members. Electrical equipment and the capacity of the faculty are necessary for installing the rooftop solar panel system. These data and information were also collected during the primary survey. Research publications, books, journal articles, and university documents such as electricity bills and other records provided secondary data.

Cost-benefit analysis is the primary analytical method that explored the financial and economic viability of transforming to solar power energy in the FSSH. The Net Present Value (NPV), Cost-Benefit Ratio (CBR), Internal Rate of Return (IRR) under both financial and economic scenarios were calculated, and MS Excel and SPSS software helped analyze the data.

## 3. DATA ANALYSIS AND DISCUSSION

### *3.1 Status of Electricity Consumption of the University*

Mihintale premises of the Rajarata University consume more electricity for academic and non-academic purposes. Being a state university, the government pays all utility costs; hence, consumers are likely free riders in the university. All faculties, hostel premises, street lighting, university canteen, library, computer laboratories, lecture halls, and washrooms in the university use electrical energy, primarily for lighting, operating equipment, and cooling purposes.

The university's electricity consumption creates costs for the government; it also generates hidden costs by damaging the environment, such as carbon emissions from burning primary energy sources when converting electricity. Electricity generation from various sources contributes significantly to $CO_2$ emissions in the environment.

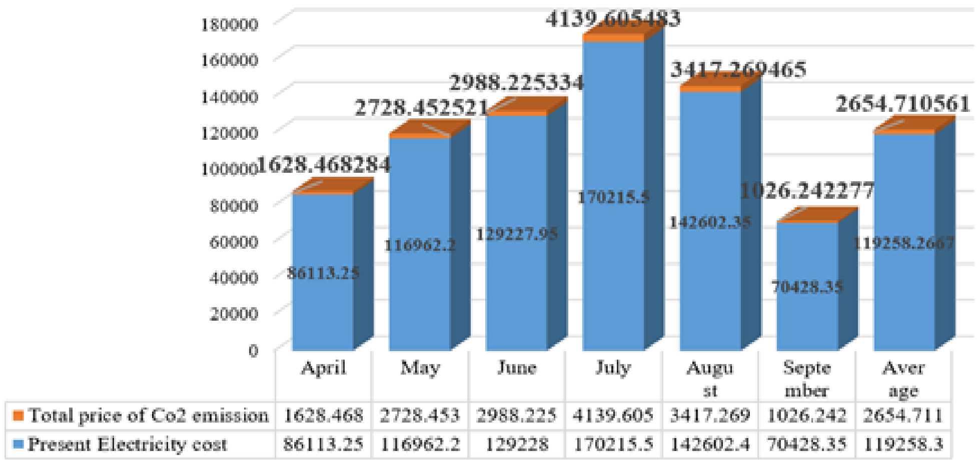
Coal burning, for instance, emits approximately 0.109 kg/kWh, while gas emits 0.078 kgCO2e/kWh. Similarly, hydropower, bioenergy, nuclear, solar, and wind energy have lower CO2 emissions, with nuclear, solar, and wind being among the lowest at 0.004-0.006 kgCO2e/kWh. It is important to note that renewable energy sources are generally considered zero emitters of CO2.

In Sri Lanka, an estimated 70% of electricity production relies on imported coal and fuel oil, contributing substantially to CO2 emissions and environmental degradation (ADB and UNDP, 2017). The Faculty of Social Sciences and Humanities (FSSH) has been a consumer of electrical energy, as detailed in Table 1 and Figure 1. The monthly electricity consumption data from 2019 for the faculty reflects various payment structures and associated carbon emissions. The reliance on electricity generated from sources with higher CO2 emissions, such as imported coal and fuel oil, indicates the potential for elevated carbon emissions from the faculty's energy consumption, impacting the natural environment.

**Table 1: Electricity consumption and carbon emission cost of the FSSH**

| | | Total cost/year |
|---|---|---|
| Units related to the source (The electricity percentage from coal burning ) | 70% | (39,916.80)LKR |
| LKR $CO_2e$/KWh | 7.98 LKR | 31,856.53 LKR |

Source: Outputs of the analysis based on Faculty electricity billing documents (2019)




Source: Author created based on available data (2019)

**Figure 1: Electricity bill payment and CO2 emission cost of the FSSH**

### *3.2 Status of the Faculty Electricity Energy Consumption*

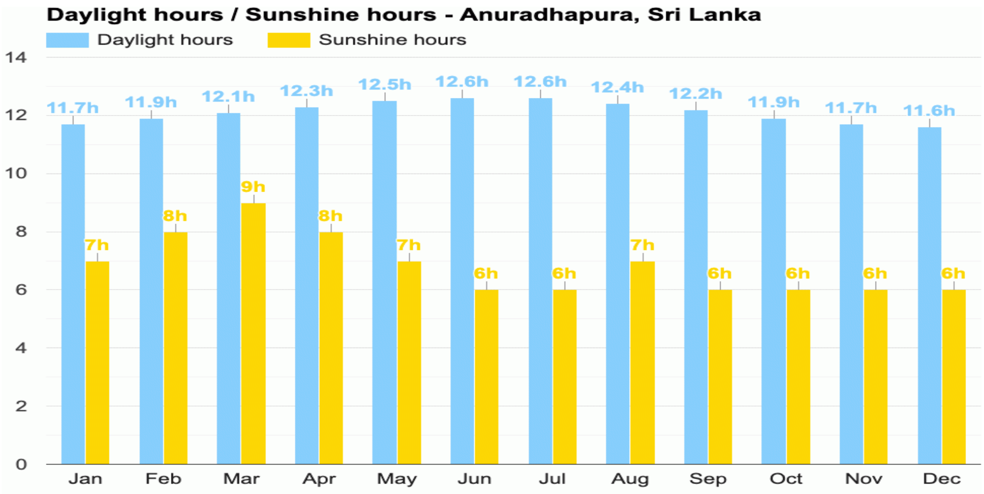
The faculty mainly uses electricity for space lighting, cooling, and other equipment like computers, printing machines, photocopy machines, and other laboratory equipment. High electricity demand is expressed for the academic purpose of the faculty, focusing on the electricity consumption related to the faculty space and equipment distribution. Comparatively, the faculty canteen, washrooms, and dining rooms consumed less electricity. The faculty of FSSH still uses fluorescent tube lights

(250 fluorescent tube lights) to light the entire faculty premises. From that, about 100 lights are used daily. Fluorescent bulbs take much time to produce whole light, while some energy is wasted as heat—its total energy capacity does not convert as lighting. For cooling purposes, the faculty uses regular AC machines. Most equipment purchased with low quotations consumes more energy to power. Low-quality equipment in the faculty is the main reason for high electricity consumption.

### *3.3 Climatic Potential for Solar Power*

The Rajarata University of Sri Lanka is located in the Dry zone of Sri Lanka. The country has natural solar power and the best sunshine hours. Solar radiation in Sri Lanka varies from 4.0 - 4.5 kWh/$m^2$/day in the lowland area (Wijesena & Amarasinghe, 2018). An area with good sunshine is necessary to generate solar power from solar cells. The university is located in the Anuradhapura district, which receives 6.5 hours of average sunshine hours per day, and some days of the year, it exceeds 8 or 9 hours.

Figure 2 illustrates the distribution of sunshine hours in Anuradhapura. This depiction of sunshine hours indicates the region's potential capacity to generate substantial solar power through solar panels. Concerning the wet zone of the country, Anuradhapura experiences comparatively lower rainfall throughout the year, which does not significantly hinder the generation of solar power from solar cells within the university area. However, the solar power generation capacity might observe a decline, particularly around December and January.




Source: Author created based on available data (2019)

**Figure 2: Daily sunshine hours in Anuradhapura District, Sri Lanka**

The rationale behind this potential decrease in solar power generation during December and January in Anuradhapura relates to seasonal variations and weather patterns prevalent in this period. These months generally coincide with the northeast monsoon season in Sri Lanka, which typically brings increased cloud cover, more frequent rainfall, and shorter daylight hours. These weather conditions, characterized by greater cloud cover and reduced sunlight, might decrease the effective generation of solar power during this period compared to other times of the year. Despite this decline, the overall solar power generation potential remains considerably high throughout the year due to Anuradhapura's generally favorable sunshine hours compared to other regions in the country.

### *3.4 Cost-Benefit Analysis for Solar Power Installation*

There is a huge potential to introduce solar power as a renewable energy source to the FSSH, mainly due to its geographical location. There is no problem choosing a place for solar installation, and the faculty rooftop is the better location for a solar layout.

However, budget allocation for solar installation is an issue. The capital cost is high for the installation in the short run, but it may create massive economic and environmental benefits in the long run. Therefore, it is necessary to analyze the cost and benefit of installing solar systems within the financial and economic cost-benefit analysis framework and identify the cash flows and cash outflows of solar energy installation.

Cash outflows encompass various expenditure categories crucial in financial assessments: capital installation costs denote initial expenses for acquiring and setting up long-term assets, while life maintenance costs signify ongoing expenses essential for asset upkeep and efficiency. Operating costs encompass routine expenses vital for day-to-day business operations. Conversely, cash inflows represent financial gains: electricity using capacity benefit denotes increased capacity efficiency, present electricity cost savings reflect reduced current expenses due to efficient practices or technologies, and carbon emission reduction benefits signify monetary gains from eco-friendly approaches. Understanding and balancing these cash outflows and inflows is pivotal in evaluating the financial viability, profitability, and sustainability of projects or business initiatives, profoundly impacting overall financial performance. Hence, these components can be further elucidated individually below.

### *3.5 Capital Installation Cost of Solar Power System*

The faculty rooftop is chosen as the most suitable place for installing the solar power system as it is the best place to lay out the solar cells. Using other university areas instead of the rooftop may damage the environment by clearing the space for a solar layout because the solar system takes up a vast area for solar cell flooring. The capacity of the rooftop is about 12000 sqft. Related to the rooftop area and electricity use capacity of the FSSH, a 132 kWp solar power capacity is suggested to the faculty.

The solar power system cost estimation was obtained from the JLanka solar installation company. Table 2 provides the cost of solar layout system capacity. Obviously, the rationale for selecting JLanka Solar Installation Company for providing the cost estimation of the solar power system is their recognized expertise, reliability in delivering accurate cost estimations, cost-effectiveness, and alignment with the project's environmental objectives, making them a fitting choice for the university's rooftop solar installation project.

**Table 2: Solar installation costs summary**

| **System capacity** | **132 kWp** |
|---|---|
| **Solar panels (330 w)** | 400 |
| **Basic system cost** | 21,216,000.00 LKR |
| **Other installation costs** | 8,033,000.00 LKR |
| **Total cost** | 29,249,000.00 LKR |

Source: Estimated by the Author based on information taken from Jlanka Company (2019)

## Maintenance Cost

Heavy maintenance after solar installation is unnecessary, but we can anticipate some solar panel losses, AC cable losses, and DC cable losses. Allocating 0.5% of the total cost of system capacity may be sufficient for the maintenance of the solar system, assuming the maintenance cost after five years of the installation.

## Operating Cost

Present technical officers in the university can operate the solar system; two laborers will be allocated for regular operation for 20 days per month with a daily wage of 1500 LKR. Knowledge of the solar system is essential for selected operators.

## Capacity Benefit

The solar installation capacity changes with the sunshine hours at the Rajarata University location. The average sunshine hour of Anuradhapura is about 6.5 hours. Assume the sunshine hours are 6 hours to compute the capacity benefit. The sunshine capacity per day is calculated using the following equation:

$$\text{Total capacity per day} = \text{Capacity of solar installation} \times \text{Sunshine hours} \quad \rightarrow \quad \textbf{(1)}$$

Table 3 expresses the solar capacity benefit, which depends on the climatic condition of the Mihintale premises.

**Table 3: The capacity of solar installation**

| **Installed kWp** | **132 kWp** |
|---|---|
| **Daily average sunshine hours in Anuradhapura** | 6 h (Depends on climatic conditions) |
| **Total kWh per day** | (132 X 6h) = 792 kWh |
| **Total kWh per month** | (792×30 d) = 23,760 kWh |
| **Total kWh per year** | (23,760×12 m) = 285,120 kWh |
| **Total generation benefit per year** | (285,120× 14.55 LKR) = 4,148,496.00 LKR |

kWp - kilowatt peak, kWh - kilowatt hours, h - hours, d - days, m – months
Source: Outputs of the analysis (2019)

## Present Electricity Cost-Saving

FSSH consumes 57024 units (57024 kWh) per year on average (Faculty electricity billing documents, 2019). After establishing the solar system, the average price per unit is about 14.55 LKR and the monthly fixed cost is 3000.00 LKR. Solar installation saves all these costs. The annual total average financial electricity cost of the FSSH, which is 1,431,099.00 LKR, can be saved after solar power installation.

## Carbon Emission Reduction (Benefit of Carbon Saving by Refraining from Present Electricity Consumption)

The university's electricity provider is the Anuradhapura Ceylon Electricity Board (CEB), sourcing power from the Lakvijaya coal power plant and various hydropower facilities in the country. Approximately 70% of the electricity in the Anuradhapura area originates from the coal power plant. Transitioning to solar power usage holds the advantage of eliminating carbon emissions, thereby negating the need for the CEB's electricity bill. This stands as a significant benefit derived from solar installation. Considering CEB's average tariff per unit, the expenses incurred due to current energy consumption from non-renewable sources can be considered the advantage of adopting solar energy. Table 4 delineates the costs associated with carbon emissions stemming from coal-powered generation.

**Table 4: Carbon emission cost-saving**

| | |
|---|---|
| **Average units per year** | 57,024 u |
| **Percentage from non-renewable** | 70% |
| **Unit related to supply source** | 3,991.60 u |
| **$CO_2e$ per kWh(kg)** | 0.109 |
| **Total emission kg $CO_2e$/kWh** | 3,991.60×0.7 = 435.093 kg $CO_2e$/kWh |
| **$CO_2e$ price per ton** | $ 40.00 |
| **$CO_2e$ price per kg** | $ 0.04409 (per unit)/ $176.0029 (total units) |
| **Sri Lanka rupee per dollar in 2019** | 181 LKR |
| **Total emission cost** | 31,856.52 |

CO2e - Carbon dioxide emission, kg - kilograms, kWh - kilowatt hours
Source: Outputs of the analysis (2019)

**Table 5. Cash inflow and outflow**

| Cash outflow | Price (LKR) | Cash inflow | Price (LKR) |
|---|---|---|---|
| Capital cost | 29,249,000.00 | Capacity benefit | 4,148,496.00 |
| Maintenance cost | 584,980.00 | Present electricity cost-saving | 1431,099.00 |
| Operating cost | 60,000.00 | Carbon saving | 31,856.53 |

Source: Outputs of analysis (2019)

The process of determining the cash outflow and inflow associated with solar power installation, as outlined in Table 5, relied upon data spanning more than 20 years. An integral aspect of this cost-benefit analysis is incorporating a discount rate. The discount rate evaluates the alteration in money's value over time when invested (Investopedia, 2017). In this analysis, the prevailing market interest rate in Sri Lanka, set at 7%, is utilized as a proxy for the discount rate. This choice enables estimating the current value of future cash flows, aligning them with their present-day worth.

The formula for NPV:

$$NPV^0 = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} \quad \rightarrow \quad (2)$$

Where,

$B_t$ - $C_t$ = Future cash flow
$r$ = Discount rate
$t$ = Time period

Net Present Value of Solar Installation:
NPV = Discounted Bnenefits– Discounted Costs
**27,340,401.08** (59,110,308.9- 31,769,907.8)

According to the financial analysis, The Net Present Value of the solar system is 27,340,401.08 LKR, which is beneficial for installation. Hence, this solar system project can be accepted and will gain this benefit after 20 years. Investing in this solar system will benefit the university's electricity supply.

The CBR is the ration between discounted benefits and the discounted costs

$$CBR = \frac{59,110,308.9}{31,769,907.8}$$

CBR = 1.86

The Financial CBR of this investment is about 1.86, presenting the project's benefit. If CBR exceeds 1.0, the project is expected to deliver a positive net present value. Investing a 1.00 rupee in the current time can take 1.86 rupees in the future.

The Internal Rate of Return (IRR) obtained from the financial cost-benefit analysis is 21.63%. This figure surpasses the applied discount rate of 7% assigned to the investment. The IRR, exceeding the discount rate, signifies a positive Net Present Value (NPV) for the project. The equation calculating the IRR sets the Net Present Value (NPV) of cash flows to zero. The IRR is the discount rate at which the NPV of all cash flows becomes zero. The rationale behind selecting the 7% discount rate as a benchmark in this context lies in its representation of the prevailing market interest rate in Sri Lanka. This rate is a proxy for evaluating the project's feasibility and potential profitability. By exceeding this rate, the IRR of 21.63% indicates a more lucrative return on the investment, emphasizing the project's viability and positive financial prospects:

$$IRR = \sum_{t-1}^{t} \frac{CF_t}{(1+r)^t} - C_0 \qquad \rightarrow \qquad \textbf{(2)}$$

Where,

$CF_t$ = Net cash inflow during the period of years
r = Discount rate
t = number of the time period
$C_{0=}$ Total initial investment cost

The economic cost-benefit analysis of the research is expressed with the external benefit of reducing carbon emissions from solar power use instead of CEB electricity supply from coal power plant. The net present value of this solar installation under the economic cost-benefit analysis is 27,677,889.62 LKR. It is represented as 21.81% of the Internal rate of return (if IRR> discount rate; NPV>0).

The cost-benefit ratio of the economic cost-benefit analysis of solar installation is 1.87; it shows the benefit of the solar layout of the FSSH. Investing a 1.00 rupee at present will gain a 1.87 benefit in the future. Based on the results, this solar power installation can be recommended under the positive net present value and and its internal rate of return exceeded the discount rate (7%). Table 6 provides the summary of the financial and economic cost-benefit analysis of establishing the solar system.

**Table 6: The estimates of financial & economic cost-benefit analysis**

| Indicators | Financial cost & benefit analysis | Economic cost-benefit analysis |
|---|---|---|
| **Net Present Value** | LKR 27,340,401.08 | LKR 27,677,889.62 |
| **Cost-benefit Ratio** | 1.86 | 1.87 |
| **Internal Rate of Return** | 21.63% | 21.81% |

Source: Outputs of analysis (2019)

Related to the above financial and economic benefits, the Faculty of Social Sciences & Humanities can have two benefits from solar power installation. First, it can solve the problem of the environmental impact of present electricity consumption, which is mainly based on non-renewable resources.

The other advantage of using solar power in universities is the potential financial benefit. If the solar panels generate more energy than the institution requires, the excess electricity can be sold back to the national grid, offsetting the cost of purchasing electricity. This additional income can be used to improve the university infrastructure, such as accommodation and facilities, and increase the university employee salaries. In addition, funds can be allocated toward students' educational needs. Adopting renewable energy sources also allows universities to improve their reputation as environmentally conscious institutions, which can attract ecologically conscious students and staff.

## 4. CONCLUSION

In conclusion, the research on "Financial and economic viability of transforming to solar energy: case study from rajarata university of sri lanka" has demonstrated the significant potential of energy efficiency and solar power as a sustainable solution for higher education institutions in Sri Lanka. The study has highlighted the high electricity consumption of universities and the adverse effects of using fossil fuels on the environment. The research findings have proved that energy-saving measures and renewable energy sources like solar power can significantly reduce carbon emissions and contribute to a more sustainable future. The study has further demonstrated the economic benefits of investing in energy-efficient technologies and solar power systems. By reducing energy waste and generating electricity through solar power, universities can save on electricity bills and redirect those funds toward other academic and research initiatives.

Overall, this research emphasizes the importance of prioritizing energy efficiency and sustainability in higher education institutions and encourages universities in Sri Lanka to consider integrating solar power as a renewable energy source. By taking action towards achieving these goals, universities can contribute to a more sustainable future and positively impact the environment and society. Based on the research findings, the study highly recommends that higher education institutions in Sri Lanka prioritize energy efficiency and consider and transform tom solar power as a renewable energy source.

The study highlights the high electricity consumption of universities and the negative impact of burning fossil fuels on the environment. By implementing energy-saving measures and transitioning to renewable energy sources like solar power, universities can significantly reduce their carbon footprint and contribute to a more sustainable future. The study demonstrates the economic benefits of investing in energy-efficient technologies and solar power systems. By reducing energy waste and generating electricity through solar power, universities can save electricity bills and redirect those funds toward other academic and research initiatives.

## REFERENCES

Asian Development Bank & United Nations Development Programme. (2017). 100% Electricity generation through renewable energy by 2050: Assessment of Sri Lanka’s Power Sector. [Online] Available at: <https://www.adb.org/sites/default/files/publication/354591/sri-lanka-power-2050v2.pdf> [Accessed: 21 September 2019].

Center for Resource Solutions (2016). Solar Energy on Campus. [Online] Available at: <https://resource-solutions.org/wp-content/uploads/2016/12/Solar-Energy-on-Campus-III.pdf> [Accessed: 05 May 2017].

Halder, P.K, Paul, N., Joardder, M. U. H., & Sarker, M. (2015). Energy scarcity and potential of renewable energy in Bangladesh. Renewable and Sustainable Energy Reviews, 51, 1636–1649. DOI: 10.1016/j.rser.2015.07.069

Hossain, K. A., 2015. Present and future of global energy sources. Journal of fundamentals of renewable energy & applications, pp. DOI:104172/2090-4541.1000171.

Investopedia. (2017). Time Value of Money. [Online] Available at: https://www.investopedia.com/terms/t/timevalueofmoney.asp [Accessed: 18 October 2017].

International Energy Agency (2018) Available at: http://www.iea.org [Accessed: 12 October 2018].

International Energy Agency (2019) Available at: http://www.iea.org [Accessed: 12 March 2019].

International Energy Agency (2023). The Solar Energy International Curriculum. [Online] Available at: <https://www.solarenergy.org/> [Accessed: 21 May 2023].

IREC (2017) 'Best Practices: The Series'. [online] Available at: <https://www.irecusa.org/best-practices-the-series/> [Accessed 26 May 2017].

IREC. (2019). Strategies for Workforce Development: A Toolkit for the Solar Industry. [Online] Available at: https://www.irecusa.org/best-practices-the-series/ [Accessed: 19 September 2019].

Ismail, A. M., Ramirez-Iniguez, R., Asif, M., Munir, A. B., & Muhammad, F. (2015). Progress of solar photovoltaic in Asian countries: A review. Renewable and Sustainable Energy Reviews, 48, 399-412.

Ministry of Power and Energy, Sri Lanka. (2023). Energy Department Sri Lanka. [Online] Available at: https://energy.gov.lk/index.php/en/ [Accessed: Insert 23 April 2023].

NREL (2017). Energy Education. [online] Available at. <https://www.nrel.gov/about/energy-education.html> [Accessed 21 February 2017].

Oleiwi, F. M., Kasim, N. K., & Atwan, A. F. (2021). PV-Solar Power Generation in Educational Institutions. Journal of Physics Conference Series, 1879(3), 032070. DOI: 10.1088/1742-6596/1879/3/032070

Pehl, M., Arvesen, A., Humpenöder, F., Popp, A., Hertwich, E. G., Luderer, G., & Edenhofer, O. (2017). Understanding future emissions from low-carbon power systems by integration of life cycle assessment and integrated energy modelling. Nature Energy. doi: 10.1038/s41560-017-0032-9

Sri Lanka Sustainable Energy Authority, Ministry of Power and Energy. (2019). Journal on Vidulka National Energy Symposium [Online] Available at: http://www.energy.gov.lk/en/energy-management/vidulka-energy-exhibition [Accessed: 08 March 2020].

Syarafina, E., Ng, S. Y., & Choong, W. W. (2010). Energy conservation opportunities in Malaysian universities. Malaysian Journal of Real Estate, 5(1).

UNDP Sri Lanka. (2018). Trilateral Cooperation on Renewable Energy in Sri Lanka. [Online] Available at: https://www.undp.org/srilanka/projects/trilateral-cooperation-renewable-energy-sri-lanka [Accessed: 08 March 2018].

Wegapitiya, W.K.H. (2017). Potentials in the Sri Lankan 'Battle of Solar' Programme and the Rooftop Initiative: Solar Power Generation Developments and Investment Opportunities in Sri Lanka. LAUGFS Holdings Limited, Sri Lanka.

Wijesena, G. & Amarasinghe, R., 2018. Solar energy & its role in Sri Lanka. International journal of engineering trends & technology, pp. 2231-5381.

## APPENDIX

**Table 7: Financial cost benefit analysis**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| <u>Costs</u> | | | | | | | | | | | | | | | | | | | | |
| **Installation Cost 132 KWP** | 29,249,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Maintenance Cost** | 0 | 0 | 0 | 0 | 0 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 |
| **Operating Cost** | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 |
| **Total Costs** | 29,309,000 | 60,000 | 60,000 | 60,000 | 60,000 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 |
| **Discount Factor (7%)** | 0.9346 | 0.8734 | 0.8163 | 0.7629 | 0.7130 | 0.6663 | 0.6227 | 0.5820 | 0.5439 | 0.5083 | 0.4751 | 0.4440 | 0.4150 | 0.3878 | 0.3624 | 0.3387 | 0.3166 | 0.2959 | 0.2765 | 0.2584 |
| **Discounted Cost** | 27,391,589 | 52,406 | 48,978 | 45,774 | 42,779 | 429,777 | 401,661 | 375,384 | 350,826 | 327,875 | 306,425 | 286,379 | 267,644 | 250,134 | 233,770 | 218,477 | 204,184 | 190,826 | 178,342 | 166,675 |
| **Total Discounted Cost** | **31,769,908** | | | | | | | | | | | | | | | | | | | |
| <u>Benefits</u> | | | | | | | | | | | | | | | | | | | | |
| **Capacity Benefit** | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 |
| **Electricity Cost Saving in Faculty** | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 |
| **Total Benefits** | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 | 5,579,595 |
| **Net Benefit** | -23,729,405 | 5,519,595 | 5,519,595 | 5,519,595 | 5,519,595 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 | 4,934,615 |
| | | | | | | | | | | | | | | | | | | | | |
| **Discount Factor (7%)** | 0.9346 | 0.8734 | 0.8163 | 0.7629 | 0.7130 | 0.6663 | 0.6227 | 0.5820 | 0.5439 | 0.5083 | 0.4751 | 0.4440 | 0.4150 | 0.3878 | 0.3624 | 0.3387 | 0.3166 | 0.2959 | 0.2765 | 0.2584 |
| **Discounted Net Benefit** | -22,177,014 | 4,821,028 | 4,505,634 | 4,210,873 | 3,935,395 | 3,288,142 | 3,073,030 | 2,871,991 | 2,684,104 | 2,508,508 | 2,344,400 | 2,191,028 | 2,047,690 | 1,913,729 | 1,788,532 | 1,671,525 | 1,562,173 | 1,459,975 | 1,364,462 | 1,275,198 |
| **Total Discounted Net Benefit** | **27,340,401** | | | | | | | | | | | | | | | | | | | |
| **NPV** | **27,340,401** | | | | | | | | | | | | | | | | | | | |
| **Cost Benefit Ratio** | **1.86** | | | | | | | | | | | | | | | | | | | |
| **Internal Rate of Return** | **21.63%** | | | | | | | | | | | | | | | | | | | |

Source: Outputs of analysis (2019)

**Table 8: Economic cost benefit analyze**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Costs** | | | | | | | | | | | | | | | | | | | | |
| **Installation Cost 132 KWP** | 29,249,000 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Component Life Maintenance** | - | - | - | - | - | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 | 584,980 |
| **Operating Cost for 2 Lab Hours** | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 |
| **Total Costs** | 29,309,000 | 60,000 | 60,000 | 60,000 | 60,000 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 | 644,980 |
| **Discount Factor (7%)** | 0.9346 | 0.8734 | 0.8163 | 0.7629 | 0.7130 | 0.6663 | 0.6227 | 0.5820 | 0.5439 | 0.5083 | 0.4751 | 0.4440 | 0.4150 | 0.3878 | 0.3624 | 0.3387 | 0.3166 | 0.2959 | 0.2765 | 0.2584 |
| **Discounted Cost** | 27,391,589 | 52,406 | 48,978 | 45,774 | 42,779 | 429,777 | 401,661 | 375,384 | 350,826 | 327,875 | 306,425 | 286,379 | 267,644 | 250,134 | 233,770 | 218,477 | 204,184 | 190,826 | 178,342 | 166,675 |
| **Total Discounted Cost** | **31,769,908** | | | | | | | | | | | | | | | | | | | |
| **Benefits** | | | | | | | | | | | | | | | | | | | | |
| **Capacity Benefit** | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 | 4,148,496 |
| **Electricity Cost Saving in Faculty** | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 | 1,431,099 |
| **CO2 Emmission Reduction** | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 | 31,857 |
| **Total Benefits** | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 | 5,611,452 |
| **Discount Factor (7%)** | 0.9346 | 0.8734 | 0.8163 | 0.7629 | 0.7130 | 0.6663 | 0.6227 | 0.5820 | 0.5439 | 0.5083 | 0.4751 | 0.4440 | 0.4150 | 0.3878 | 0.3624 | 0.3387 | 0.3166 | 0.2959 | 0.2765 | 0.2584 |
| **Discounted Benefit** | 5,244,347 | 4,901,259 | 4,580,616 | 4,280,950 | 4,000,887 | 3,739,147 | 3,494,530 | 3,265,916 | 3,052,258 | 2,852,577 | 2,665,960 | 2,491,552 | 2,328,553 | 2,176,218 | 2,033,848 | 1,900,793 | 1,776,442 | 1,660,226 | 1,551,613 | 1,450,106 |
| **Total Discounted Benefit** | **59,447,797** | | | | | | | | | | | | | | | | | | | |
| **Net Benefit** | -22,147,242 | 4,848,853 | 4,531,638 | 4,235,176 | 3,958,108 | 3,309,370 | 3,092,869 | 2,890,532 | 2,701,431 | 2,524,702 | 2,359,535 | 2,205,173 | 2,060,909 | 1,926,083 | 1,800,078 | 1,682,316 | 1,572,258 | 1,469,400 | 1,373,271 | 1,283,431 |
| **Total Net Benefit** | **27,677,890** | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| **Payback Period** | -22,147,242 | -17,298,389 | -12,766,751 | -8,531,575 | -4,573,467 | -1,264,097 | **6.41 Years** | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| **NPV** | 27,677,890 | | | | | | | | | | | | | | | | | | | |
| **Cost Benefit Ratio** | 1.87 | | | | | | | | | | | | | | | | | | | |
| **Internal Rate of Return** | 13.84% | | | | | | | | | | | | | | | | | | | |

Source: Outputs of analysis (2019)