PERFORMANCE EVALUATION OF EXISTING SOLAR POWER PLANTS IN THE ADYPU TECHNICAL CAMPUS

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Abstract

The evaluation of the functioning of the solar panels that are currently installed at the ADYPU Technical Campus is essential given the growing importance of solar energy in the field of renewable energy. The objective of this study is to thoroughly examine several factors—such as efficiency, rate of deterioration, environmental effects, and technological innovations—that affect the performance of solar panels. This assessment explores how temperature fluctuations, shading, soiling, aging, and other environmental factors affect the longevity and efficacy of solar panels through a thorough analysis of real-world performance and a thorough review of the literature and empirical data. The evaluation's conclusions not only help those involved in the solar energy industry make educated decisions by highlighting the advantages and disadvantages of current solar panel technologies, but they also give academics and decision-makers useful information for developing strategies to improve the sustainability and efficiency of solar energy systems in the face of a rapidly changing energy landscape.

Keywords: *Solar panels, real-world, performance, solar power plants, ADYPU, technical campus.*

1. INTRODUCTION

Installing solar power plants on ADYPU Technical Campuses improves manageability by addressing power issues with sustainable power sources. By producing clean power from daylight, schools can significantly reduce their carbon footprint. Additionally, by completing the power plant's necessary output, the school can save money on energy costs over time by reducing its reliance on more expensive or traditional power sources.

A fantastic way to boost sustainability and lower the carbon footprint of educational institutions is to install solar power plants on campus. These solar power plants produce clean, affordable power by harnessing the sun's energy. This minimizes the school's reliance on intermittent, non-sustainable power sources and the byproducts of burning fossil fuels, both of which are good for the planet.

If a school can meet all of its electrical needs using solar power, it can save a lot of money on energy bills in the long run. This is justified by a decreased reliance on the most expensive power sources, which over time results in significant expense reserve money. Generally speaking, the placement of solar power plants on college campuses contributes to the positive trend toward a more practical and conservative future.

The poly-glass-like solar panel wafers are created by dissolving many silicon pieces together. These wafers surround a single silicon PV cell composed of various silicon precious stones; this type of solar board is currently used on campus. The efficiency of these panels ranges from 13–16%.

It can create three distinct sizes of poly-glass-like solar panels: 90 watts at 12 volts for poly780x668x30 mm, 115 watts at 12 volts for poly1015x668x30 mm, and 175 watts at 12 volts for poly 1485x668x30 mm. The maximum output of these panels is 250 to 300 watts for 90 watts at 12 volts.

The ADANI power plant, which has a maximum power output of 341.48 watts, provides the solar energy on our campus. The model number of this board is asp-7-340, and it has a lower welfare level. The maximum power current of the solar board in use right now is 9.10A. Furthermore, 37.54V is the voltage for power that stands out the most. This 23 kilogramme solar board is heavy.

1.1. In our ADYPU technical campus solar plants are installed in three areas:

i. **Engineering building**:

There are 272kWh of solar panels placed in the engineering building, generating 272x3.63x30 = 29620.8 units each month.

Figure 1: Engineering building

ii. Dental block:

All 142.8kWh of solar panels in the Dental Block are installed, resulting in 142.8x3.63x30 = 15550.92 units/month.

Figure 2: Dental Block

iii. Parking:

163.2 kWh of solar panels are installed in Stopping, resulting in 163.2 x 3.63 x 30 = 17772.48 units produced each month.

Figure 3: Parking

2. LITERATURE REVIEW

Karn et.al (2022). An empirical analysis of the impact of energy price shocks for sustainable energy on the macroeconomics of South Asian countries is carried out by Their study looks at how changes in energy costs affect economic indicators in the context of sustainability, which is an important area of energy economics. The research sheds light on the regional dynamics of energy markets and their wider implications for sustainable development by concentrating on South Asian nations.

Sharma et.al (2023) By utilising GD and LM-artificial neural networks to create solar power forecasting models, make a contribution to the field of renewable energy. Accurate forecasting is essential for effective energy management since solar energy is becoming more and more important. In order to improve the dependability and effectiveness of solar power generation systems, the study suggests predicting algorithms that can adjust to a variety of weather situations.

Giri et.al (2023) investigate the potential of algae as a superfood in a different field, namely in relation to biomass and bioenergy solutions for sustainability and climate change mitigation. Algae are a greener alternative to traditional food and energy production techniques, as they are a viable source of nourishment and biodiesel. The study clarifies the many advantages of algae, from their nutritional worth to their ability to support the ecosystem.

Ahmadi et.al (2018), An analysis of solar power technology for the production of electricity is presented by who also offer insights into the technology's advantages, disadvantages, and potential. Informed decision-making and policy development require an awareness of the technological advancements and obstacles in the field of solar energy, as this clean and renewable energy source continues to gain popularity. Researchers, decision-makers, and industry participants interested in the advancement and application of solar power technology will find the review to be a useful resource.

Priya et.al (2020), Lastly, a study on the use of machine learning methods in stress prediction is presented by with an emphasis on the creation of an improved support vector machine method. Research on stress prediction is important and has applications in psychology, healthcare, and workplace management, among other domains. The study advances predictive models for stress assessment by utilising machine learning techniques, which may have implications for tailored healthcare and stress management strategies.

3. RESEARCH METHODOLOGY

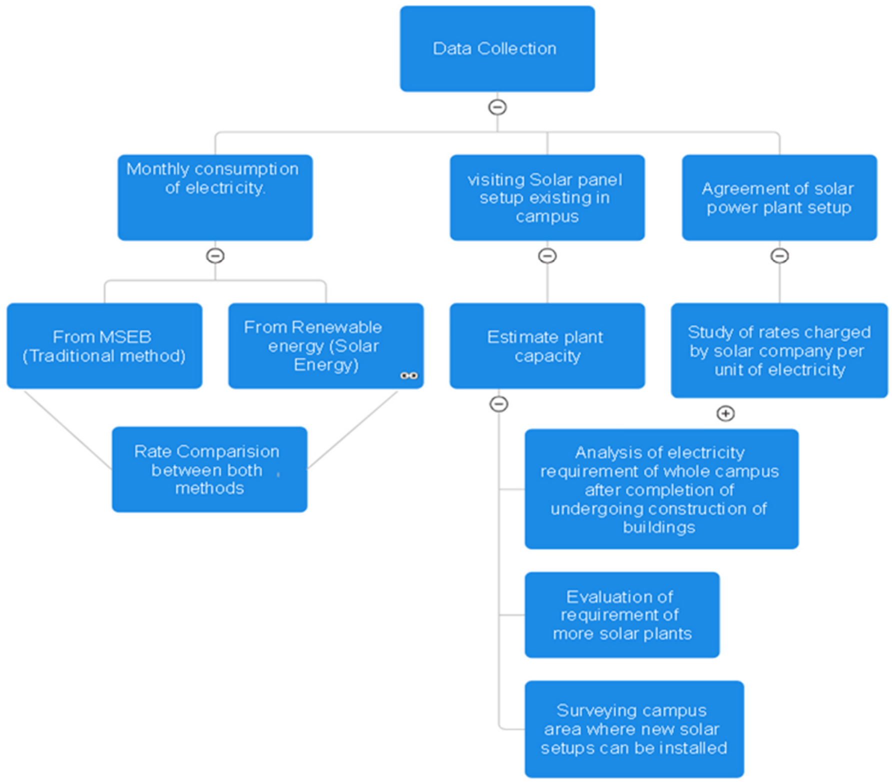

Figure 4: Flow chart of Methodology

3.1.Minimize carbon footprints

The total amount of ozone-depleting compounds, such as carbon dioxide, that individuals, groups, or events release into the atmosphere as a result of their activities is known as their "carbon impression."

Byproducts of fossil fuels contribute to global climate change, which affects biological systems and human health. They may result in extreme weather patterns, increasing sea levels, and air pollution. It's critical to reduce emissions using workable methods and technologies.

i. According to the IPCC, each kWh of power generated by roof solar generates 41 grammes of CO2 reciprocals. Either way, that figure is subject to change. There are many methods to reduce solar panels' carbon footprint (which has likely decreased since the IPCC revealed the 41 grammes).

At every level, there are open possibilities to reduce the carbon footprint of solar panels.

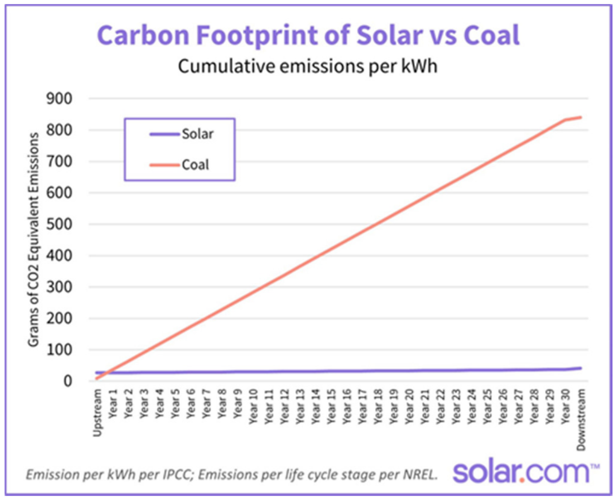

Figure 5: Carbon footprint of Solar vs Coal

According to the IPCC, in terms of CO_2 emissions per kWh of power produced, household solar panels have a carbon footprint that is many times lower than that of gaseous fuel and several times lower than that of coal.

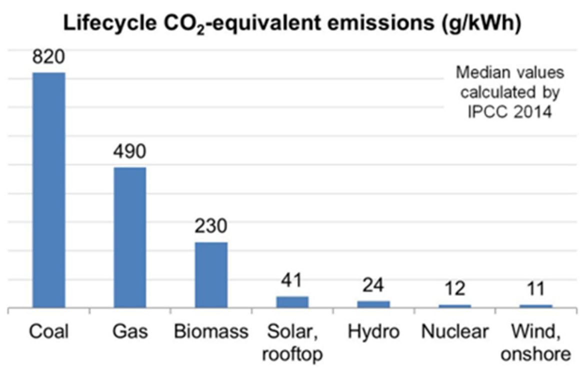

Figure 6: Life-cycle CO2-equivalent emission (g/kWh)

The carbon footprint of solar panels is minimal, as they produce approximately 41g of CO_2 per kilowatt-hour of operation. This is not precisely the carbon output from coal-fired power plants by several times.

In this way, the byproducts of fossil fuels in multiple months

Byproducts of fossil fuels when solar energy is used to generate power

= 80,000 x 41

= 32,80,000 g CO_2

Byproducts of fossil fuels when coal is used to generate electricity: 80000 x 820

= 6,56,00,000 g CO_2

Thus, the decrease in emanation is

= 6,56,00,000 - 32,80,000

= 6,23,20,000 g CO_2.

3.2.Monthly Electricity consumption of ADYPU Technical campus

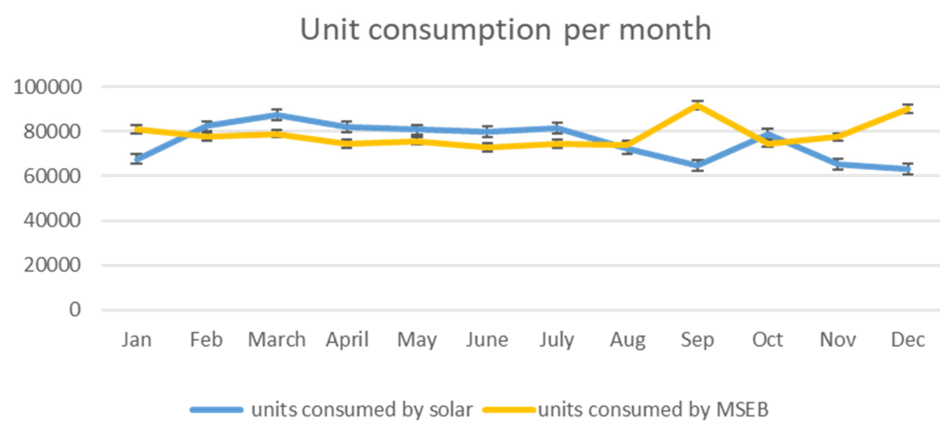

Figure 7: Unit Consumption Per Month

Table 1: Comparison of unit consumption per month

months	units consumed by solar	units consumed by MSEB
Jan	67791	80850
Feb	82357	77545
March	87319	79059
April	82154	74488
May	80747	75870
June	79821	72842
July	81700	74648
Aug	72406	73944
Sep	64639	91630
Oct	79021	74751
Nov	65156	77522
Dec	63288	90187

3.3.Required solar panel:

A. ADYPU Technical Campus typically uses 154144 units of electricity each month, or 5138 units per day. …………………………….…………………[1]

B. Currently using units from ongoing jobs projects.

i. Hospital (700 beds)

since 1sq.ft of hospital requires 0.0849 kWh/sqft /day

we know,

Area of hospital = 50x62 m

= 3100 sq.m

= 3100x10.76

= 33356 sq. ft

Therefore, Electricity consumption = 33356x0.0849

= 2832 units/day………………………...[2]

ii. Head office

since 1sq.ft of head office requires 0.020 kWh/sq.ft /day

we know,

Area of head office = 33x33 m

= 1089 sq.m

= 1089x10.76

= 11717 sq. ft

Therefore, Electricity consumption = 11717x0.020

= 234 units/day…………………………...[3]

C. Therefore, required units per day in ADYPU Technical campus = [1] + [2] + [3]

= 5138 + 2832 + 234

= 8204 units/day

D. 1kWh generates 4units per day, therefore 8204/4 = 2051 kWh

Presently the 640kWh capacity of a solar power plant is already installed on ADYPU campus. Based on our teams' observation, if the management plans to cater to the needs of upcoming consumption we propose 2051 – 640 = 1411 kWh solar plant in our campus to fulfill our power needs.

In our opinion the suitable area for the installation of a solar plant as follows:

We suggest 1kWh of solar panel requires 100.ft of land

Therefore, we need 1411x100 = 141100 sq. Ft area

- **Suitable areas –**

Hospital terrace area = 50x62 m

= 3100 sq m

= 3100x10.76

= 33356 sqft..[1]

Head office terrace area = 33x33 m

= 1089 sq m

= 1089x10.76

= 11717 sq-ft ……………………. ……..[2]

ADYPU school terrace area = 38.15x38.15 m

= 1455x10.76

= 15660sqft …………………………[3]

Ajeenkya D. Y. Patil University Building (ULC) terrace area = 21.20 x 53.15

= 1126 sq m

= 1126 10.76

=12124sqft …[4]

Engineering workshop terrace area = 46x 37 m

= 1702

= 1702x10.76

= 18313sqft …[5]

Engineering parking area = 100x58 m

= 5800 m

= 5800x10.76

= 62408 sq-ft …[6]

Therefore, the required Area for installing 1411 kWh of solar panels in ADYPU Technical campus is

= [1] + [2] +[3]+[4]+[5]+[6]

=33356+11717+15660+12124+18313+62408

=153578 sq-ft

3.4.Power Factors

i. Sanctioned Load

Authorised Burden refers to the heap in kW that the buyer and the conveyance licensee typically agree upon.

ii. Contract Demand

The term "contract demand " refers to the interest in kilowatt (kW) or kilo-Volt Amperes (kVA), which is typically agreed upon by the client and the circulation licensee as stated in the agreement or agreed upon through other written correspondence.

iii. Billing Demand - HT tariff categories

From month to month Charging Request: The greater of the corresponding:

- Genuine interest held during the month from 0600 to 2200 hours;
- 75% of the highest charging request recorded in the previous eleven months;
- subject to agreement interest restrictions
- 70% of the agreement interest.

For FY 2024-25: 75%

iv. Maximum demand

The highest interest rate is the highest degree of electricity use for a certain duration. This time frame (15 or 30 minutes) is not available.

v. Power Factor Computation

In cases where the inserted meter produces an absurd typical Power Element assessment, the accompanying equation will be utilised to determine the typical Power Variable during the charging period:

P.F. = Real power / apparent power.

Total (kWh)

Average Power Factor =Total (kVAh)

Wherein the kVh is = $\sqrt{\sum(KWh)2 + \sum(RkVh\ Lag + RkVh\ Lead)2}$

vi. Wheeling charge

"Wheeling charges" are the costs associated with moving electricity from a power plant to final consumers.

vii. E.D. (Electricity duty) –

E.D. is the total sum of energy, wheeling, and interest charges. The power obligation for the H.T class is 21%.

viii. TOD Tariff –

Power rates in these taxes vary depending on the time of day. The tax is reduced by up to 20% during the day, which benefits customers. However, in the evening, the duty increases by an equivalent amount.

ix. Tax on sale –

In the H.T. category, the tax on the sale of electricity and electricity duty is 19.04 PS/U.

4. ANALYSIS

Comparison of solar and MSEB electricity pricing.

Table 2: Comparison of units consumed by different sources

Month	Units consumed by Solar	Units consumed by MSEB
JAN	67741	80850
FEB	82357	77545
MARCH	87319	79059
APRIL	82154	74488
MAY	80747	75870
JUNE	79821	72842
JULY	81700	74648
AUG	72406	73944
SEP	64639	91630
OCT	79021	74751
NOV	65156	77522
DEC	63288	90189
Average of 12 months	75529	78611

A. Calculation for electricity generated by solar-

As per the agreement, tariff is 5.7 per unit, which is constant for 20 years.Therefore,
Monthly bill = 456000
And hence, the yearly bill INR = 5472000

B. Calculations for electricity generated by MSEB

i. Demand charges

2020-21 =400
2021-22 =445
2022-23 = 494
2023-24 = 499
2045-25= 549
i.e. 10% increment per year

ii. Energy Charge

2020-21 = 8.9
2021-22 = 9.4
2022-23 = 9.88
2023-24 = 10.40
2024-25 = 10.93
I.e. 5% increment per year.

iii. Electricity duty-21%

iv. Wheeling charges -0.6 rs/unit

v. Tax on sale-19.04 ps/unit.

- For Year 1st (20-21)

1. Demand charges

=467.5 x 400

=1,87,000 /-

2. Energy charges

=80000 x 8.9

=7,12,000 /-

3. E.D. (electricity duty)

= (Demand Charges + Wheeling Charges + Energy Charges) x21%

=(187000 + 48000 + 712000)

= 198870 /-

4. Tax on sale = 15200 /-

Monthly bill for (2020 - 21) =1113070

Yearly bill = 13356840 /-

- For Year 2nd (21-22)

1. Demand charges

=510 x 445

=2,26,950/-

2. Energy charges

= 80000 x 9.4

=7,52,000/-

3. E.D. (electricity duty)

= (Demand Charges + Wheeling Charges + Energy Charges) x21%

=(2,26,950 + 48,000 + 7,52,000)

= 2,15,659 /-

4. Tax on sale

=15200 /-

Monthly bill for (2021 - 22) = 1,20,9809

Yearly bill = 1,45,17,708/-

Increment of 8.7% per year till year 2023 -24

- For year 5th (24-25)

1. Demand charges

=595 x 549

=3, 26,655 /-

2. Energy charges

= 80000 x 10.93

=8,74,400 /-

3. E.D. (electricity duty)

= (Demand Charges + Wheeling Charges + Energy Charges) x21%

= (3,26,655 + 48,000 + 8,74,400)

= 2,15,659/-

4. Tax on sale

=15200/-

Monthly bill for (2024 - 25) = 14,78,556/-

Yearly bill = 1,77,42,672 /-

- For year 6th (25-26)

1. Demand charges

=595 x 604

=3,59,320/-

2. Energy charges

= 80000 x 11.5

=9,20,000 /-

3. E.D.(electricity duty)

= (Demand Charges + Wheeling Charges + Energy Charges) x21%

= (3,59,320 + 48,000 + 9,20,000)

=2,78,737 /-

4. Tax on sale

=15200/-

Monthly bill for (2025 - 26) = 15,73,257

Yearly bill = 1,88,79,084 /-

Increment of 6.4% per year till year 2039 - 40

5. RESULTS AND DISCUSSION

1. Reduction of carbon footprints by using electricity generated by solar panels instead of electricity generated by coal = <u>6,23,20,000 g CO2</u>

2. Required solar panels and area for installing new solar panel setup for future electricity requirement of ADYPU Technical campus -

i. Require solar panels = <u>2051 kw</u>
ii. required area for installation = <u>153578 sq ft.</u>

3. Cost saving using power factors -

i. Contract demand should be reduced to reduce demand charges

ii. Power factor (P.F.) should be between = <u>(9.95 to 1)</u>

APFC panel can be applied to continuously monitor the power factor

iii. Time of day (TOD) charges -

heavy activities of campus which require large electricity should be done in time between

= <u>10 PM to 6 AM</u>

4. Comparison of renewable source (solar) with traditional method (MSEB)

Table 3: Comparison of rates in 20 years

Year	Amount to be paid for electricity generated by solar	Amount to be paid for electricity generated by MSEB
20 - 21	54,72,000	1,33,56,840
21 - 22	54,72,000	1,45,17,708
22 - 23	54,72,000	1,57,80,748
23 - 24	54,72,000	1,71,53,673
24 - 25	54,72,000	1,77,42,672
25 - 26	54,72,000	1,88,79,084
26 - 27	54,72,000	2,00,87,345
27- 28	54,72,000	2,13,72,935
28 - 29	54,72,000	2,27,40,803
29 - 30	54,72,000	2,41,96,214
30 - 31	54,72,000	2,57,44,772
31 - 32	54,72,000	2,73,92,437
32 - 33	54,72,000	2,91,45,553
33 - 34	54,72,000	3,10,10,869
34 - 35	54,72,000	3,29,95,565
35 - 36	54,72,000	3,51,07,281
36 - 37	54,72,000	3,73,54,147
37 - 38	54,72,000	3,97,44,812
38 - 39	54,72,000	4,22,88,480
39 - 40	54,72,000	4,49,94,940
Total Amount in 20 Years	**10,94,40,000**	**53,16,06,881**

The above table depicts that by using electricity which is generated by solar power instead of buying it from MSEB we will save

= 53,16,06,881 - 10,94,40,000

=42,21,66,881 /-   (I.e. 5x saving in 20 years)

6. FINDINGS AND SUGGESTIONS

- **Findings:**

1. When solar power is used instead of conventional coal-based electricity generation, carbon footprints are greatly reduced.
2. To meet its energy needs, the college needs more solar panels with a 1411 kWh capacity.
3. Energy bills can be reduced by using time-of-day tariffs and optimal power factors.
4. Using solar power yields significant cost savings over 20 years as compared to buying electricity from MSEB.

- **Suggestions for Performance Evaluation:**

1. Evaluate current solar power plants' efficacy by conducting efficiency evaluations.
2. Put in place regular maintenance plans to guarantee the longevity and optimum performance of solar panels.
3. Set up data analytics and monitoring systems to track performance in real-time and optimize operations.
4. Effectively integrate the infrastructure of the campus with solar power generation.
5. Involve instructors and students in learning projects that emphasize sustainability and renewable energy.

7. CONCLUSION

In light of the findings and concepts presented, it is clear that ADYPU Technical Campus's acceptance of solar power has a crucial commitment in terms of reducing carbon footprints, meeting energy needs, and achieving considerable expenditure reserve funds. Understanding the financial and environmental advantages of solar energy over traditional coal-based power, the university can take proactive steps to become more versatile and sustainably powered. However, to increase the effectiveness and sufficiency of currently operating solar power plants, it is essential to oversee meticulous productivity assessments, execute standard maintenance schedules, and implement monitoring frameworks for real-time performance monitoring. Furthermore, aligning the solar power age with the campus framework and enlisting students and staff in educational initiatives would not only improve the university's sustainability efforts but also foster a culture of growth and environmental care. Overall, ADYPU Technical Campus may be ready for a more sustainable future and reap financial and environmental benefits by adopting these recommendations and harnessing solar energy's potential.

References

[1] *Ahmadi, M. H., Ghazvini, M., Sadeghzadeh, M., Alhuyi Nazari, M., Kumar, R., Naeimi, A., & Ming, T. (2018). Solar power technology for electricity generation: A critical review. Energy Science & Engineering, 6(5), 340-361.*

[2] *Chengwei Liu, Yixiang Chan, Syed Hasnain Alam Kazmi, Hao Fu, "Financial Fraud Detection Model: Based on Random Forest," International Journal of Economics and Finance, Vol. 7, Issue. 7, pp. 178-188, 2015.*

[3] *Ganesh Kumar and P.Vasanth Sena, "Novel Artificial Neural Networks and Logistic Approach for Detecting Credit Card Deceit," International Journal of Computer Science and Network Security, Vol. 15, issue 9, Sep. 2015, pp. 222-234*

[4] *Giri, S. U., Hadapad, N. G. K., Akhade, A., & Bhilare, P. (2023). Algae as Superfood. In Biomass and Bioenergy Solutions for Climate Change Mitigation and Sustainability (pp. 129-147). IGI Global.*

[5] *Gyusoo Kim and Seulgi Lee, "2014 Payment Research", Bank of Korea, Vol. 2015, No. 1, Jan. 2015.*

[6] *Hitesh D. Bambhava, Prof. Jayeshkumar Pitroda, Prof. Jaydev J. Bhavsar (2013), "A Comparative Study on Bamboo Scaffolding and Metal Scaffolding in Construction Industry Using Statistical Methods", International Journal of Engineering Trends and Technology (IJETT) – Volume 4, Issue 6, June 2013, Pg.2330-2337.*

[7] *Lal Karn, A., Kondamudi, B. R., Gupta, R. K., Pustokhin, D. A., Pustokhina, I. V., Alharbi, M., ... & Sengan, S. (2022). An Empirical Analysis of the Effects of Energy Price Shocks for Sustainable Energy on the Macro-Economy of South Asian Countries. Energies, 16(1), 363.*

[8] *P. Ganesh Prabhu, D. Ambika, "Study on Behaviour of Workers in Construction Industry to Improve Production Efficiency", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD), Vol. 3, Issue 1, Mar 2013, 59-66.*

[9] *Sharma, N., Puri, V., Mahajan, S., Abualigah, L., Zitar, R. A., & Gandomi, A. H. (2023). Solar power forecasting beneath diverse weather conditions using GD and LM-artificial neural networks. Scientific reports, 13(1), 8517.*

[10] *T. Mohana Priya, Dr. M. Punithavalli & Dr. R. Rajesh Kanna, Machine Learning Algorithm for Development of Enhanced Support Vector Machine Technique to Predict Stress, Global Journal of Computer Science and Technology: C Software & Data Engineering, Volume 20, Issue 2, No. 2020, pp 12-20.*

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