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Solar-Powered Coin-Operated Mobile Charging Station for Sustainable Energy Access and Resilience

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Abstract

This study centers on the creation of a cutting-edge coin-operated mobile gadget charging station, harnessing the inexhaustible power of solar energy via an integrated storage battery. The primary objective is to champion solar energy as a sustainable off-grid power source with boundless growth potential. Moreover, this innovative solution extends its utility to the commercial realm, where users can access it for a nominal fee, ensuring their mobile gadgets remain charged for specified periods. In addition to its commercial viability, this charging station also serves as a crucial lifeline during unforeseen calamities and prolonged power outages, offering an essential emergency charging station. Its self-sufficient design allows it to continually charge mobile devices in the presence of sunlight. Whether it's day or night, the coin-operated mobile gadget charging station stands ready to power up small electronics and mobile devices, ensuring uninterrupted connectivity.

Keywords: *Creation, Coin-Operated, Mobile Gadget Charging Station, Solar Energy, Integrated Storage Battery, Sustainable, Off-Grid, Growth Potential, Commercial Realm, Nominal Fee*

1. Introduction

Renewable power generation can help countries meet their sustainable development goals through provision of access to clean, secure, reliable and affordable energy. Solar technology is very popular nowadays and growing day by day (Lohani et al., 2023). Solar powered gadgets are also taking attention of people and a use of solar energy is taking places where no electric power is available but also in cities. Many countries are aggressively producing renewable energy nowadays (Liet al., 2023).

On December 16, 2008, during the Second Regular Session of the Fourteenth Congress Republic Act No. 9513 also known as the *Renewable Energy Act of 2008* was enacted. "An Act Promoting the Development, Utilization and Commercialization of Renewable Energy Resources and for Other Purposes" which aims in its declaration of policy the following: (a) accelerate the exploration and development of renewable energy resources such as, but not limited to, biomass, solar, wind, hydro, geothermal and ocean energy sources, including hybrid systems, to achieve energy self-reliance, through the adoption of sustainable energy development strategies to reduce the country's dependence on fossil fuels and thereby minimize the country's exposure to price fluctuations in the international markets, the effects of which spiral down to almost all sectors of the economy; (b) increase the utilization of renewable energy by institutionalizing the development of national and local capabilities in the use of renewable energy systems, and promoting its efficient and cost-effective commercial application by providing fiscal and non-fiscal incentives; (c) encourage the development and utilization of renewable energy resources as tools to effectively prevent or reduce harmful emissions and thereby balance the goals of economic growth and development with the protection of health and the environment; and (d) establish the necessary infrastructure and mechanism to carry out the mandates specified in this act and other existing laws.

Governments across the Asia Pacific region is continuing the push for greater renewable energy contributions to domestic electricity demand (Millison et al., 2022). While the deal flow has been lower than expected over the last six months, there have been positive signs in several countries that local developers are very active at the approval level. International developers are increasingly taking advantage of the many government and market incentives for renewable energy investment and investing alongside locals (Rathore&Panwar, 2022).

Solar power is pollution-free during use (Sunte, 2022). Photovoltaic (PV) installations can operate for many years with little maintenance or intervention after their initial set-up, so after the initial capital cost of building any solar power plant, operating costs are extremely low compared to existing power technologies (Aboagyeet al., 2022).

Modern technology has brought a huge impact on the way of life of many people in the globe (Su et al., 2022). Paradigms of such advancement in technology are the gadgets like mobile phones, iPhones, iPods and tablet computers that make living a whole lot better than it was before.

The researchers' idea was due from the need of a green energy source to provide sustainable power to charge mobile gadgets during power outages and/or where electrical power is not available for a reasonable amount of time.

The idea or a device that will charge mobile gadgets started when the Guimaras State University participated in the annual Manggahan Festival booth display. The first prototype was then started and tested on September 2012. By April 2013, the first operational prototype was displayed during the said activity.

The researcher opted to engage in the field of Electronics and renewable energy, specifically the realm of mobile gadgets that is undeniably one of the most commonly used devices of today's generation. Recharging a mobile phone is one of the primary concerns of the people who use it in a daily basis.

The study is focused on the application of photovoltaic (solar) power generation as an off-grid electrical source to power the study because it is a ubiquitous source of energy, with the huge potential of significant contribution to the development of Green Technology.

The study will also facilitate the understanding of the significance of promoting renewable energy as alternative source of electrical power and encourages further development, innovation and production of renewable energy systems.

In this premise, the researcher has developed the concept of developing an innovative design of the system using renewable energy from the sun which is one of the most abundant sources of energy. On this account, the researcher deals with the means of recharging mobile gadgets using solar power. Thus, this study is conducted.

Significance of the Technology

The technology of a solar-powered, coin-operated mobile charging station carries significant implications and benefits in several key areas:

It champions solar energy as a sustainable and eco-friendly off-grid power source. By harnessing inexhaustible solar power, this technology contributes to reducing dependence on non-renewable energy sources, mitigating environmental impacts, and advancing the adoption of clean energy solutions.

This innovative solution extends its utility to the commercial sector, offering a potentially profitable business model. Entrepreneurs can establish and operate these charging stations, generating income by providing charging services to customers. This not only benefits businesses but also boosts local economies.

The technology ensures that users have consistent access to charged mobile gadgets. In today's interconnected world, reliable access to mobile devices is crucial for communication, information dissemination, and various daily activities. This technology helps bridge the digital divide, ensuring that even in remote areas, people can stay connected.

The charging station doubles as an essential emergency power source during unforeseen calamities and extended power outages. It provides a lifeline for individuals in crisis situations, enabling them to communicate, access vital information, and seek assistance. This can be a crucial tool for disaster management and relief efforts.

By relying on solar energy, this technology aligns with the growing global commitment to sustainability and environmental conservation. It reduces greenhouse gas emissions and contributes to the reduction of the carbon footprint associated with energy generation.

The technology enhances the resilience of communities by providing access to power even in adverse conditions. This resilience is vital for individuals, businesses, and community infrastructure, ensuring that essential services remain operational when traditional power sources fail.

As more solar-powered charging stations are deployed, it can inspire innovation and the development of related technologies, creating a ripple effect of technological advancement. This can lead to the creation of new jobs and opportunities in the renewable energy sector.

The technology serves as a practical model for educational institutions and researchers to explore the integration of renewable energy sources and commercial viability. It offers valuable insights for academic studies, contributing to knowledge and innovation in the field of renewable energy and technology.

3. Results and Discussion

The table presents data on test trials for the charge rate of a generic 2nd generation mobile phone at various time intervals and corresponding prices. Each row represents a different replication, and the percentages indicate the amount of charge achieved in that particular amount of time and at the specified cost. The "Average Charge %" column provides the mean charge percentage across all three replications for each time interval and price point.

Here are some key observations and points for discussion:

Time vs. Charge Percentage: As expected, there is a clear positive correlation between the time spent charging and the charge percentage achieved. Longer charging times result in higher charge percentages, and this relationship is fairly consistent across replications.

Pricing Impact: The table also highlights the cost associated with each time interval. Users can pay a specific amount (in Philippine Pesos) to achieve a particular charge percentage. For instance, users can pay 1.00Php for a 6-minute charge, which typically results in a 22% charge.

Replication Variability: It's essential to note that there is some variability between replications for the same time and price points. This variation could be due to several factors, including variations in the phone's initial battery state, minor differences in charging efficiency, or other external factors.

Average Charge Percentage: The "Average Charge %" column provides a useful summary of the data, allowing you to see the overall trend. It's evident that, on average, charging for 24 minutes (at 4.00Php) results in a 52% charge, while charging for 30 minutes (at 5.00Php) reaches 62%. This information can help users make informed decisions about how much to pay for the desired charge level.

Economic Implications: This data can be used to assess the cost-effectiveness of using this charging station. Users can decide whether it's worth spending extra for a higher charge percentage or if a lower percentage is sufficient for their needs.

Usability and Convenience: The data can also be used to determine the charging station's usability. Users might want to charge their phones quickly with a higher percentage, or they might be willing to wait longer for a lower cost.

Table 1. Test trials for charge rate of generic 2nd generation mobile phone

Charge Time	6 minutes (1.00Php)	12 minutes (2.00Php)	18 minutes (3.00Php)	24 minutes (4.00Php)	30 minutes (5.00Php)
Replication 1	20%	26%	41%	50%	60%
Replication 2	23%	29%	44%	52%	60%
Replication 3	22%	30%	45%	55%	65%
Average Charge %	22%	28%	43%	52%	62%

Figure 1. Test trials for charge rate of generic 2nd generation mobile phone

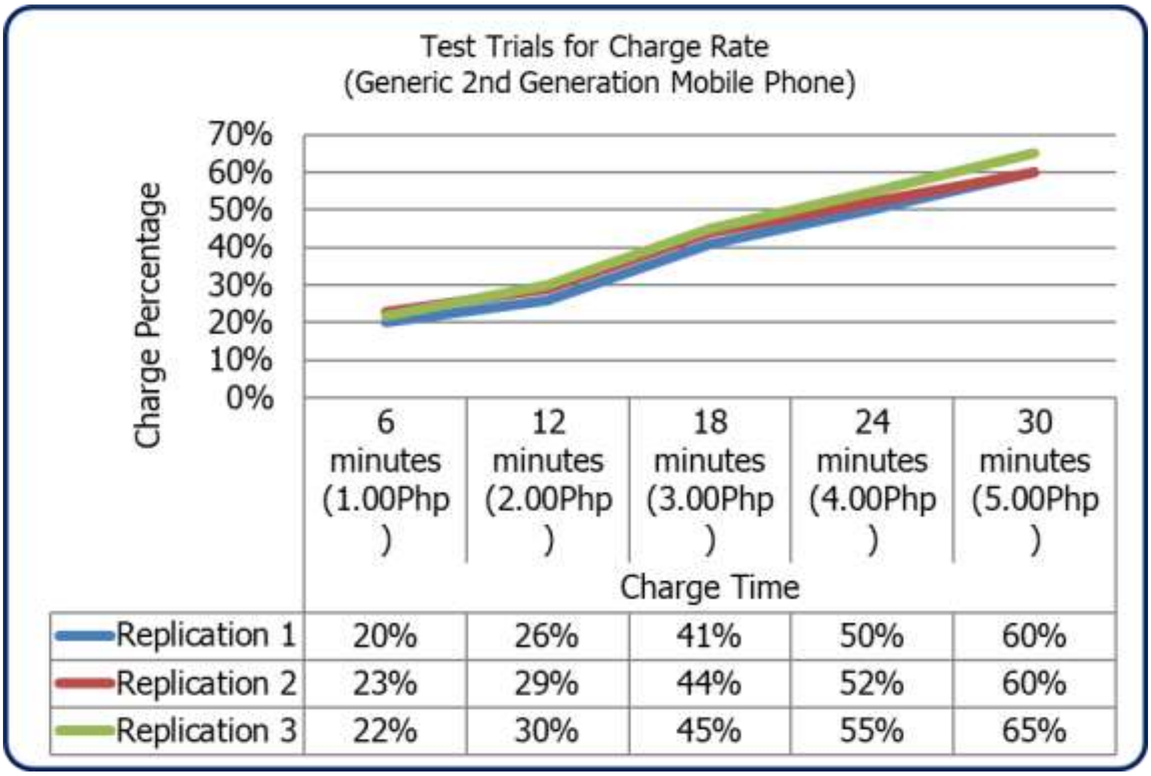

Figure 1 illustrates a graph depicting the results of charging test trials conducted in three separate replications using a 2nd generation mobile phone. The graph displays the charge percentages achieved for replication 1, which ranged from 20% to 60%, across charging durations of six to thirty minutes. Replication 2 exhibited charge percentages ranging from 23% to 60% for the same time durations, while replication 3 recorded percentages ranging from 22% to 65% within the same charging time frame.

Table 2 presents data on test trials for the charge rate of a generic 3rd generation mobile phone. Similar to Table 1, it provides information on charge times, corresponding prices, replication results, and the average charge percentage across all replications. Here are some key observations and points for discussion:

Comparison with 2nd Generation: It's interesting to note that this table presents data for a 3rd generation mobile phone, allowing for a comparison with the 2nd generation phone from Table 1. The data can be used to assess whether the newer generation phone charges more efficiently or whether there are other differences in charging behavior.

Time vs. Charge Percentage: As with the 2nd generation phone, there is a clear positive correlation between the time spent charging and the charge percentage achieved. Longer charging times result in higher charge percentages, and this relationship is consistent across replications.

Pricing Impact: Like in Table 1, this table also highlights the cost associated with each time interval. Users can pay varying amounts (in Philippine Pesos) to achieve different charge percentages, and they can use this information to make cost-effective decisions based on their desired charge level.

Replication Variability: As with the 2nd generation phone, there is some variability between replications for the same time and price points. This variability could stem from factors like initial battery state, charging efficiency, or external variables.

Average Charge Percentage: The "Average Charge %" column summarizes the data and reveals the overall trend. For example, on average, charging for 24 minutes (at 4.00Php) results in a 51% charge, while charging for 30 minutes (at 5.00Php) reaches 55%.

Usability and Convenience: Users of the 3rd generation phone can use this data to determine the charging station's usability, balancing charging time and cost based on their individual needs and preferences.

Consistency with 2nd Generation: A comparison between the two tables can reveal whether the 3rd generation phone charges more efficiently or whether there are other factors affecting charging rates. The data can also help users make informed decisions about which generation of phone to use based on their priorities.

Table 2. Test trials for charge rate of generic 3rd generation mobile phone

Charge Time	6 minutes (1.00Php)	12 minutes (2.00Php)	18 minutes (3.00Php)	24 minutes (4.00Php)	30 minutes (5.00Php)
Replication 1	20%	26%	41%	49%	55%
Replication 2	23%	29%	44%	51%	54%
Replication 3	22%	30%	45%	52%	55%
Average Charge %	**22%**	**28%**	**43%**	**51%**	**55%**

Figure 2. Test trials for charge rate of generic 3rd generation mobile phone.

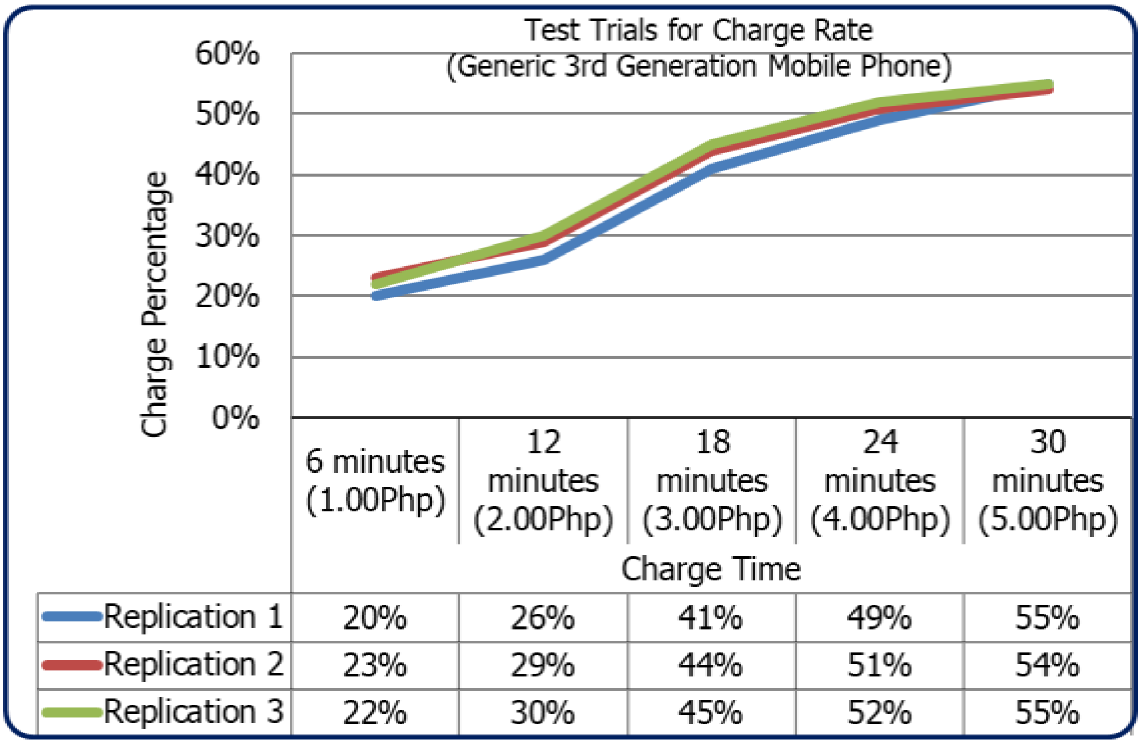

Figure 2 displays a graph portraying the results of charging test trials performed across three separate replications using a 3rd generation mobile phone. The graph showcases the charge percentages achieved in replication 1, spanning from 20% to 55%, across charging durations ranging from six to thirty minutes. Similarly, replication 2 yielded charge percentages ranging from 23% to 51% for the same time intervals, while replication 3 exhibited percentages ranging from 22% to 55% over the same duration.

Table 3 provides data on test trials for the charge rate of a generic 4th generation mobile phone. As with the previous tables, it includes information on charge times, associated prices, replication results, and the average charge percentage across all replications. Here are key observations and discussion points:

Comparison with Previous Generations: This table introduces data for a 4th generation mobile phone, allowing for comparisons with the 2nd and 3rd generation phones presented in previous tables. Comparing the charging rates and efficiency between different generations can offer insights into technological advancements.

Time vs. Charge Percentage: The data continues to show a positive correlation between the time spent charging and the charge percentage achieved. Longer charging durations result in higher charge percentages, a consistent pattern seen across replications.

Pricing Impact: The table highlights the pricing for different time intervals. Users can observe how varying the amount they pay (in Philippine Pesos) affects the charge percentage they achieve.

Replication Variability: As with the previous tables, there is variability between replications for the same time and price points. Factors like initial battery state, charging efficiency, or external conditions can contribute to this variability.

Average Charge Percentage: The "Average Charge %" column summarizes the data, showing the overall trend. For instance, on average, charging for 30 minutes (at 5.00Php) results in a 53% charge.

Usability and Efficiency: Users can use this data to assess the usability and efficiency of the charging station for 4th generation mobile phones, making informed decisions based on their specific charging needs.

Generational Comparisons: By comparing this table with Tables 1 and 2, users and researchers can determine whether the 4th generation phone charges more efficiently than its predecessors. These comparisons can help inform choices based on charging speed and cost.

Table 3. Test trials for charge rate of generic 4th generation mobile phone

Charge Time	6 minutes (1.00Php)	12 minutes (2.00Php)	18 minutes (3.00Php)	24 minutes (4.00Php)	30 minutes (5.00Php)
Replication 1	15%	26%	35%	40%	51%
Replication 2	17%	29%	34%	42%	54%
Replication 3	12%	24%	36%	40%	55%
Average Charge %	**15%**	**26%**	**35%**	**41%**	**53%**

Figure 3. Test trials for charge rate of generic 4th generation mobile phone

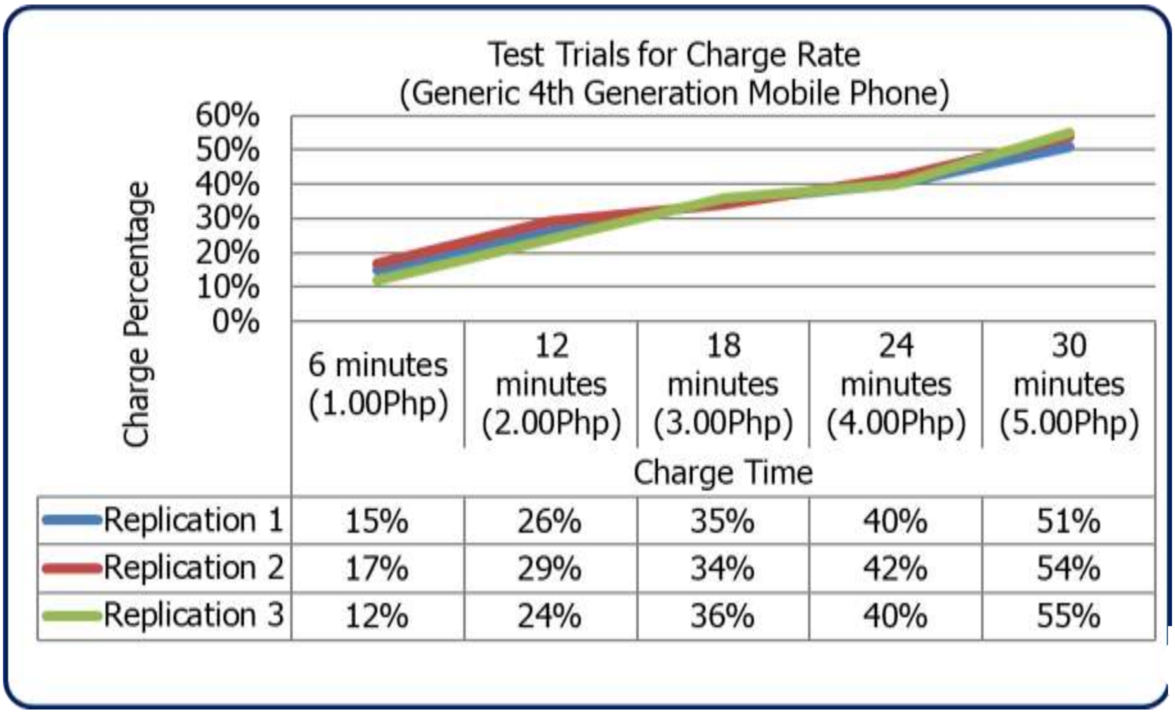

Figure 3 illustrates a graph representing the outcomes of charging test trials conducted across three distinct replications using a 4th generation mobile phone. The graph presents the charge percentages obtained in replication 1, spanning from 15% to 51%, for charging durations of six to thirty minutes. In replication 2, the charge percentages ranged from 17% to 54% within the same time frame, while replication 3 demonstrated percentages ranging from 12% to 55% over the identical thirty-minute charging period.

Based on the data and information gathered, the following findings are presented:

1. Manufacturability/ Economy

Most of the circuit can be manufactured fairly easily. The components are readily available in the market. The solar-powered coin-operated charging station has a potential for commercial use based on the testing and deployment conducted.

2. Compatibility to various brands and models of mobile gadgets

Based on the information and data gathered, the solar-powered coin-operated charging station encountered no issues on the compatibility to various brands and models of mobile gadgets commercially available in the market.

3. Sustainability and Maintenance

The solar-powered coin-operated charging station can easily sustain itself. No maintenance was required until after many uses whenever the storage battery batteries are past their lifetime and need to be replaced. Furthermore, the storage battery of the system can sustain operation for three (3) days with minimal sunlight.

Charging connectors are relatively fragile which are prone to misuse by delinquent users, additional insulation/ binder should be provided.

4. Environmental

Overall, this solar-powered coin-operated charging station has a net positive effect on the environment, as it promotes the use of clean and renewable energy

from the sun thus significantly contributing to the Guimaras State University vision of promoting green technology.

5. Social and Political

The primary use for this study is that it was used as an alternative source to charge mobile gadgets such as cell phones, cameras, etc. for when the grid power is not available all the time or during long electrical power outages. The solar-powered coin-operated charging station has the potential to help provide power source to remote or far-flung areas such as island barangays of Guimaras.

4. Conclusion

Based on the results obtained, the following conclusions are made:

1. There are no compatibility problems with a wide range of commercially available mobile gadgets, regardless of their brands and models.
2. The construction of the solar-powered, coin-operated charging station is straightforward and adaptable for both personal and commercial applications.
3. The solar-powered, coin-operated charging station demonstrates cost-effectiveness, particularly in terms of its sustainability and low maintenance requirements.
4. This charging station, which leverages solar energy, aligns with the green technology vision of Guimaras State University, making it an environmentally friendly power source.

Recommendations

In the light of the findings and conclusions drawn in this study, the following recommendations are offered.

1. The production and installation of the solar-powered coin-operated charging stations to strategic places for communal or commercial purpose should be initiated.
2. Promotion of the solar-powered coin-operated charging station in far flung and island barangays of Guimaras is recommended.
3. Additional security feature such as CCTV camera within the system is recommended to deter delinquent users from vandalizing the system.
4. Patenting of the solar-powered coin-operated charging station by the Guimaras State University is likewise recommended.
5. Research in this area concerns everyone; hence, further studies should be made in line with green technology and promotion of renewable energy.

References:

Aboagye, B., Gyamfi, S., Ofosu, E. A., &Djordjevic, S. (2022). Investigation into the impacts of design, installation, operation and maintenance issues on performance and degradation of installed solar photovoltaic (PV) systems.*Energy for Sustainable Development*, 66, 165-176.

Li, X., Raorane, C. J., Xia, C., Wu, Y., Tran, T. K. N., &Khademi, T. (2023). Latest approaches on green hydrogen as a potential source of renewable energy towards sustainable energy: Spotlighting of recent innovations, challenges, and future insights. *Fuel*, 334, 126684.

Lohani, S. P., Gurung, P., Gautam, B., Kafle, U., Fulford, D., &Jeuland, M. (2023). Current status, prospects, and implications of renewable energy for achieving sustainable development goals in Nepal.*Sustainable Development*, 31(1), 572-585.

Millison, D., George, L., Acharya, J., &Wijayatunga, P. (2022).Enabling policy and regulatory environment for solar power development: Lessons in Asia-Pacific region.Solar Compass, 2, 100023.

Rathore, N., &Panwar, N. L. (2022). Outline of solar energy in India: advancements, policies, barriers, socio-economic aspects and impacts of COVID on solar industries. *International Journal of Ambient Energy*, 43(1), 7630-7642.

Su, C. W., Yuan, X., Umar, M., &Lobonţ, O. R. (2022). Does technological innovation bring destruction or creation to the labor market?.*Technology in Society*, 68, 101905.

Sunte, J. (2022). The Design of 1 MW Solar Power Plant.