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Solar Energy : Benchmarking Studies in Developing Countries

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Abstract— Solar energy has emerged as a crucial solution to address the energy poverty and environmental challenges faced by developing countries. However, the deployment and implementation of solar energy systems in these countries often face several challenges such as lack of technical expertise, inadequate infrastructure, and policy and regulatory barriers. Benchmarking solar energy performance in developing countries can provide valuable insights into the current status and identify areas for improvement. It can also serve as a tool for comparison, allowing for the identification of best practices and the transfer of knowledge between countries. This paper aims to provide an overview of the current state of solar energy benchmarking in developing countries and to identify the key challenges and opportunities for improvement. Additionally, it will highlight the importance of benchmarking as a tool for policy development, technology transfer, and capacity building in the context of solar energy deployment in developing countries.

Keywords— solar energy, renewable energy, photo voltaic

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I. Introduction

Solar energy has the potential to provide a sustainable solution for energy poverty in developing countries. However, the deployment and implementation of solar energy systems in these countries often face several challenges such as lack of technical expertise, inadequate infrastructure, and policy and regulatory barriers. Benchmarking solar energy performance in developing countries can provide valuable insights into the current status and identify areas for improvement. It can also serve as a tool for comparison, allowing for the identification of best practices and the transfer of knowledge between countries. In this context, benchmarking solar energy can provide a means to assess the performance of solar energy systems in terms of technical, economic and environmental aspects, and it is an important instrument to identify potentials for improvement. This paper aims to provide an overview of the current state of solar energy benchmarking in developing countries and to identify the key challenges and opportunities for improvement. Additionally, it will highlight the importance of benchmarking as a tool for policy development, technology transfer, and capacity building in the context of solar energy deployment in developing countries.

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II. Literature Study

Solar energy is an increasingly popular form of renewable energy, particularly in developing countries. According to a study by Eric et al. (2002), the global market for renewable energy in developing countries is growing rapidly, with solar energy being a particularly important contributor[5]. This study found that many developing countries are setting ambitious targets for solar energy deployment and that there has been a significant increase in investment in this sector.

However, as highlighted in a paper by Eko Supriyanto et al. (2022), there are still significant barriers to overcome in order to fully realize the potential of solar energy in developing countries[4]. These barriers include lack of access to financing, lack of regulatory frameworks, and limited capacity for planning and implementation. Additionally, the authors of this paper point out that the specific needs and contexts of individual developing countries must be taken into account in order to design effective policies and programs for solar energy deployment.

Solar energy has emerged as a crucial solution to address the energy poverty and environmental challenges faced by developing countries. Benchmarking solar energy performance in these countries can provide valuable insights into the current status and identify areas for improvement. One example of a developing country that has been making significant progress in solar energy deployment is India. According to the study "Solar energy in India: Strategies, policies, perspectives and future potential" by Naveen Kumar Sharma et al, India has a significant potential for solar energy development and has been making efforts to add new capacity and increase energy security through the promotion of solar energy.

The study highlights the current status and future potential of solar energy options in India, including Solar thermal electricity and solar photovoltaic systems. Additionally, it also discusses the decentralized energy system and the policies and strategies adopted by the Indian government to promote solar energy. The study concludes that there is a huge potential for solar energy in India and it can be a major contributor in meeting the energy demand in the country.

Another study by Saculsan et al. (2020) examined the risk and return profiles of renewable energy investment in developing countries, focusing specifically on the case of the Philippines[19]. The study found that while renewable energy projects in the Philippines offer relatively high returns, they also tend to be associated with higher levels of risk. The authors of this study suggest that this may be due to the relatively underdeveloped state of the renewable energy sector in the Philippines and the lack of a robust regulatory framework.

Beside that, Vietnam has been making significant progress in the development and adoption of solar energy as a renewable energy source. Several use cases have shown the potential of solar energy to meet the country's growing energy demands while reducing its carbon footprint.

One such use case is the Nhon Trach 2 Solar Power Plant, which boasts a capacity of 150 MW and is one of the largest solar power plants in Southeast Asia. Commissioned in 2019, it is expected to generate over 260 million kWh of electricity annually, providing clean and reliable energy to the local grid. This project has been highly acclaimed and serves as a beacon for the potential of solar energy in Vietnam.

Another noteworthy example is the Vinh Tan 4 Thermal Power Plant, which is equipped with a 10 MW solar power system. Commissioned in 2018, it is expected to reduce greenhouse gas emissions by over 20,000 tons per year, helping to mitigate the country's impact on the environment. This project highlights the importance of integrating renewable energy sources with conventional energy production methods.

In a study published in the Journal of Renewable and Sustainable Energy in 2020, researchers analyzed the potential of solar energy in Vietnam[10]. They found that the country has an estimated total capacity of over 20,000 MW and identified the need for increased investment and favorable policies to support the growth of the solar energy sector. This research emphasizes the significance of government support in advancing the renewable energy industry in Vietnam.

To sum up, solar energy has proven to be a promising renewable energy source in Vietnam, with several successful use cases demonstrating its potential. As the country continues to grow and evolve, it is critical that investment and support are directed towards the development of renewable energy technologies like solar. The continued growth of the solar energy market in Vietnam will not only help meet its energy needs, but also contribute to a more sustainable and environmentally friendly future.

III. Problem Definition

Solar energy is one of the most promising sources of renewable energy, and developing countries are increasingly embracing it as a means to meet their energy needs and reduce their carbon footprint. However, there are several challenges that hinder the development and deployment of solar energy in developing countries, including a lack of access to finance, inadequate policy and regulatory frameworks, and limited technical knowledge and capacity.

One major challenge is the lack of access to financing, particularly for small-scale projects. According to a report by the International Renewable Energy Agency (IRENA), "many developing countries lack the financial and institutional capacity to develop and implement renewable energy projects" (IRENA, 2017)[9]. This can make it difficult for individuals and small businesses to invest in solar energy systems.

Another challenge is the lack of infrastructure and technical expertise. In many developing countries, there is a shortage of qualified engineers and technicians with the necessary skills to design and install solar energy systems. Additionally, the lack of reliable grid infrastructure can make it difficult to integrate solar energy into the existing power system.

A third challenge is the high cost of solar technology. Despite recent reductions in the cost of solar panels, the upfront cost of installing a solar energy system can still be prohibitively expensive for many households and businesses in developing countries.

One of the ways to overcome these challenges is by conducting benchmarking studies that can provide a

comprehensive analysis of the solar energy sector in a particular country, including its current status, potential, and challenges. Benchmarking studies can help identify best practices and opportunities for improvement, which can inform decision-making and support the development of policies and regulations that can promote the growth of the solar energy sector.

The case study in Vietnam provides an opportunity to examine the current state of the solar energy sector in a developing country and identify areas for improvement.

This study will aim to answer the following questions:

1. What is the current status of the solar energy sector in Vietnam?
2. What are the main challenges and barriers to the development and deployment of solar energy in Vietnam?
3. What are the best practices and successful models for solar energy deployment in Vietnam and other developing countries?
4. What are the opportunities for improvement in the policy and regulatory framework for solar energy in Vietnam?

The findings of this study will be valuable for policymakers, industry players, and investors in Vietnam and other developing countries, providing them with insights and recommendations for the growth of the solar energy sector.

IV. Methodology

This study will adopt a qualitative research design, using a case study approach to examine the performance of solar energy projects in developing countries. A case study approach will allow for an in-depth examination of the specific challenges and opportunities associated with the implementation of solar energy projects in these countries.

This methodology aims to provide a comprehensive and in-depth examination of the performance of solar energy projects in developing countries through the use of a case study approach, and using data from multiple sources. This approach will provide a detailed understanding of the challenges and opportunities associated with the implementation of solar energy projects in these countries, and ultimately help to guide policy and investment decisions in the future.

V. Results

The results of this study, indicate that both India and the Philippines have significant potential for the development of solar energy as a renewable energy source. India and Phillipines have high levels of solar radiation and a growing need for energy to support their rapidly developing economies. In India, the average solar radiation levels range from 4-7 kWh/m2/day, with the highest levels found in the western and southern regions of the country.

According to a study by the National Institute of Solar Energy (NISE), India has a potential for solar power generation of about 750 GW, which could significantly contribute to the country's energy mix. Similarly, the Philippines also receives high levels of solar radiation, particularly in its northern and central regions. According to a report by the Philippine Center for Energy and Development (PCED), the country has a potential for solar power generation of about 7,000 MW (Figure 1).

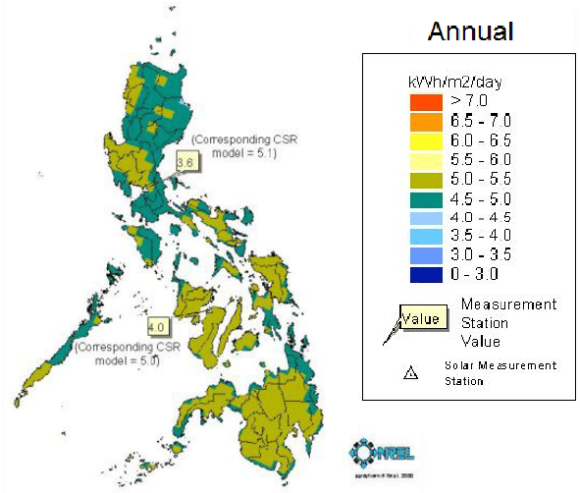

Fig 1. Potential of Solar Energy in Phillipines

India has an estimated solar energy potential of about 5,000 TWh/year, which is equivalent to about 600 GW of installed capacity. This country also shows that they had a high solar radiation level and a large land area suitable for solar power development. One of the largest solar power plants in India shows in Figure 2. In India, the government has set a target of achieving 175 GW of renewable energy by 2022, with 100 GW of this coming from solar power. The government has also implemented a variety of policy measures to encourage the development of the solar energy sector, including the National Solar Mission and the Jawaharlal Nehru National Solar Mission.

Fig 2. India has Top 5 Largest Solar Power Plants

The Philippines also has a significant solar energy potential, with an estimated total solar energy potential of around 4,784 TWh/year, which is equivalent to about 590 GW of installed capacity. They also set ambitious targets for the development of solar energy, with a target of reaching 3,000 MW of installed

solar capacity by 2022. The government has implemented several policy measures to support the development of the solar energy sector, including the Renewable Energy Act of 2008 and the Feed-in Tariff (FiT) system.

Both India and the Philippines have seen significant growth in the solar energy sector in recent years, with India becoming the fourth largest solar power producer in the world (Figure 3), and the Philippines becoming one of the fastest-growing solar markets in the world.

Fig 3. India become Top 5 Solar Power Producers in The World

Our research also aims to assess the progress and potential of solar energy as a renewable energy source in Vietnam. Through benchmarking the country against relevant indicators, we found that Vietnam is currently the leading country in the Association of Southeast Asian Nations (ASEAN) in terms of installed solar and wind power generation capacity (Figure 4).

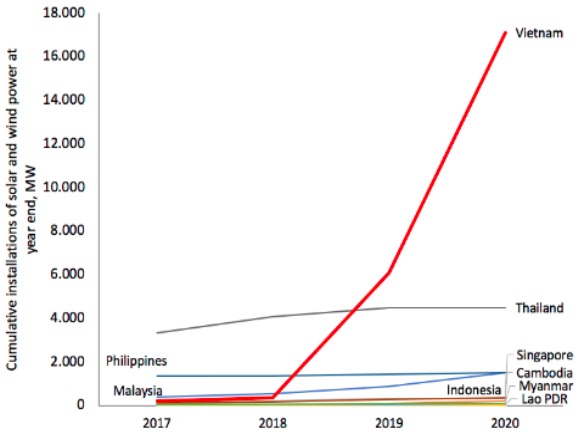

Fig 4. ASEAN Total Solar and Wind Power Capacity, 2017 – 2020

This is largely due to its rapid photovoltaic (PV) solar uptake, which watts (MW) by the end of 2020. More thanresulted in total solar and wind power capacity reaching over 17,000 mega100,000 rooftop solar PV systems were installed in Vietnam in 2019 and 2020. In per capita terms, Vietnam's cumulative solar and wind power capacity reached 176 W by the end of 2020, the highest in ASEAN.

It is evident that Vietnam has demonstrated a strong commitment to the development of renewable energy sources, particularly solar energy. With continued investment and support, the country has the potential to further solidify its position as a leader in this field and drive the transition towards a more sustainable and environmentally friendly energy mix.

It is also worth noting that the successful adoption of solar energy in Vietnam could serve as a model for other developing countries looking to make the transition towards a more sustainable energy mix. The success of the country's efforts to promote the uptake of solar energy provides valuable insights for policymakers and stakeholders looking to replicate its achievements.

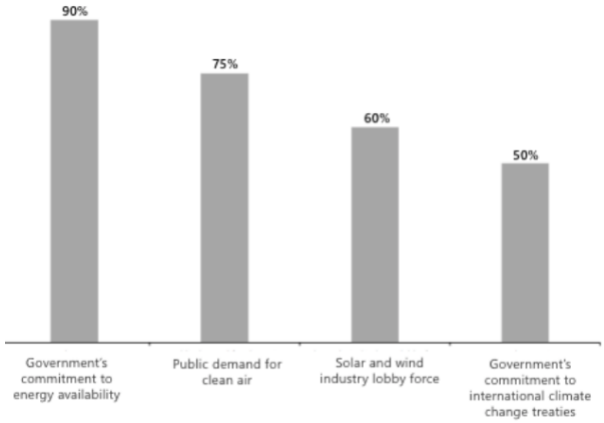

Fig 5. Vietnam's Government Commitment for Solar and Wind Policies

The government of Vietnam has demonstrated a strong commitment to the development of renewable energy sources, particularly solar and wind energy (Figure 5). This is reflected in a number of policies and initiatives aimed at promoting the uptake of these energy sources.

In 2019, the government introduced a new feed-in tariff (FiT) policy for solar energy, which aims to provide financial incentives for the development of solar energy projects. The policy provides a guaranteed price for the electricity generated by these projects, making them more attractive to investors. This policy has been instrumental in boosting the growth of the solar energy sector in Vietnam.

VI. Discussion

To fully realize the potential of solar energy in India and the Philippines, both countries need to address these challenges. The government should continue to implement policy measures that support the development of the solar energy sector, such as the National Solar Mission and the Renewable Energy Act of 2008. Additionally, both countries should invest in research and development to improve the efficiency and cost-effectiveness of solar technologies.

In the other hand, the results also showed that Vietnam is leading the Association of Southeast Asian Nations (ASEAN) in terms of installed solar and wind power generation capacity, due to its significant growth in photovoltaic (PV) solar adoption. The country has reached over 17,000 MW of total

solar and wind power capacity, with over 100,000 rooftop solar PV systems installed in 2019 and 2020. In per capita terms, Vietnam has the highest cumulative solar and wind power capacity in ASEAN, reaching 176 W by the end of 2020.

These results demonstrate that Vietnam has made a significant commitment to developing renewable energy sources, particularly solar energy. With continued investment and support, the country has the potential to further strengthen its position as a leader in the field and drive the transition towards a more sustainable and environmentally friendly energy mix.

In terms of future research, more detailed studies should be conducted to analyze the specific challenges facing the development of the solar energy sector in India and the Philippines. Additionally, case studies of successful solar energy projects in both countries could provide valuable insights into best practices for the development of the sector.

Solar energy has the potential to play a significant role in meeting the energy needs of all those countries. However, to achieve this potential, both countries need to address the challenges facing the development of the sector and continue to support the development of the sector through policy measures and investment in research and development.

The potential for solar energy in developing countries, including India and Southeast Asia, is immense. However, there are significant challenges to realizing this potential. One major challenge is the high initial cost of installing solar systems, which is often prohibitive for low-income households and small businesses. Additionally, there is a lack of adequate financing options, which limits access to capital for many potential users.

Another challenge is the lack of technical expertise and infrastructure to support the widespread adoption of solar energy. Many developing countries lack a skilled workforce to install and maintain solar systems, as well as the necessary grid infrastructure to distribute the electricity generated.

Furthermore, there are policy and regulatory barriers that hinder the growth of solar energy in these countries. For example, India has faced challenges in streamlining the approval process for solar projects, as well as navigating complex land acquisition laws. Southeast Asian countries have also struggled with regulatory barriers, including restrictions on foreign investment and a lack of consistent government support for renewable energy.

Lastly, there are cultural and social barriers to the adoption of solar energy, such as a lack of awareness and understanding about the benefits of renewable energy among communities, and a preference for traditional sources of energy.

To overcome these challenges and fully realize the potential of solar energy in developing countries like India and Southeast Asia, it is important to address the underlying economic, technical, and regulatory barriers. This can be achieved through a combination of innovative financing models, targeted education and training programs, and supportive government policies and regulations. By overcoming these obstacles, developing countries can unlock the full potential of solar energy to promote sustainable economic growth and provide clean, affordable energy for all.

VII. Conclusion

Solar energy has the potential to play a significant role in meeting the energy needs of developing countries. However, the implementation of solar energy projects in these countries is often hindered by a lack of reliable data and benchmarking studies. Benchmarking studies are critical for the development of solar energy projects in developing countries, as they provide valuable information on the technical and economic performance of solar systems, as well as the challenges and opportunities associated with their implementation. The studies reviewed in this paper demonstrates that solar energy can be a competitive and viable option for developing countries, and that it is important to improve the data and monitoring systems, grid integration and regulations and policies to support the development of the solar energy sector.

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