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Grounded Theory Exploration and SWOT Analysis for the Strategic Development of Photovoltaic Solar Energy in Myanmar

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Authors' contributions

This work was carried out in collaboration among all authors. Author MTN designed the study, conducted data collection, and performed the initial analysis. Authors SSM and HWWK contributed to refining the research methodology and assisted in the data analysis. Author RD provided critical revisions and guidance throughout the manuscript preparation process. All authors read and approved the final manuscript.

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ABSTRACT

This study, conducted from January 2023 to August 2024, examines the strategic development of photovoltaic (PV) solar energy in Myanmar through Grounded Theory and SWOT analysis. By utilizing in-depth interviews with stakeholders, site visits, and a comprehensive literature review, the research identifies key themes influencing PV solar adoption, including public perception, policy barriers, and technological challenges. The findings from Grounded Theory revealed significant

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concerns related to high upfront costs, regulatory uncertainties, and limited local expertise. However, opportunities such as decentralized energy systems, agricultural applications, and international partnerships offer promising solutions for overcoming these barriers. The SWOT analysis highlights strengths like Myanmar's abundant solar resources and government support, while weaknesses include insufficient infrastructure and high initial investment. Opportunities lie in technological advancements and global renewable energy trends, while threats such as political instability and the absence of net metering policies persist. The study concludes that targeted financial incentives, improved policy frameworks, and international collaboration are essential to advancing PV solar deployment in Myanmar. Additionally, building local expertise and simplifying regulatory processes are critical to ensuring the country fully capitalizes on its solar potential, enabling a transition to a sustainable and reliable energy future.

Keywords: Photovoltaic solar energy; grounded theory; SWOT analysis; Myanmar; renewable energy; strategic development.

1. INTRODUCTION

1.1 Context and Importance of Renewable Energy in Myanmar

Myanmar holds immense potential for solar energy development, but the development of PV solar projects faces significant challenges, including high upfront costs, policy uncertainty, and infrastructural limitations. Recent research indicates that Myanmar's utility-scale solar sector is still in its early stages, with opportunities arising from the country's rich solar resources but hindered by weak regulatory frameworks [1]. Additionally, the energy sector must contend with fluctuating fuel prices, political instability, and an over-reliance on hydropower, which makes the grid vulnerable to natural disasters and seasonal changes [2]. Furthermore, frequent blackouts and limited access to electricity, particularly in rural areas, highlight the urgent need for sustainable and reliable energy solutions [3]. In this context, photovoltaic (PV) solar energy presents a key opportunity for Myanmar to diversify its energy mix, enhance energy security, and reduce its carbon footprint [4,5].

1.2 Overview of Photovoltaic Solar Energy

Photovoltaic (PV) solar energy is a technology that converts sunlight directly into electricity using solar panels composed of semiconductor materials. This technology has garnered significant global attention due to its potential to provide clean, renewable, and increasingly cost-competitive energy [6]. For countries like Myanmar, where solar irradiation levels are high, PV solar energy presents a viable solution to meet the growing energy demand [4]. The deployment of PV solar technology can play a crucial role in mitigating the effects of climate change, reducing dependence on imported fossil fuels, and contributing to the socio-economic development of the country by creating jobs and improving access to electricity in remote areas [5].

1.3 The Challenges of PV Solar Adoption in Myanmar

Solar power has been identified as a key solution to Myanmar's energy crisis, particularly in providing off-grid energy solutions for rural areas, where access to electricity remains limited. Reports suggest that solar energy offers a more reliable and cost-effective solution compared to the long and expensive timelines of hydropower or LNG projects [7]. However, the unclear policy frameworks and lack of investor confidence continue to pose significant barriers to the growth of the sector [8]. Myanmar must address these barriers through better policy alignment and investment strategies that capitalize on the country's vast solar potential [9].

Despite its evident advantages, the adoption of PV solar energy in Myanmar faces several significant challenges. These include high initial investment costs, limited technical expertise, regulatory and policy barriers, and a lack of awareness and public acceptance [4]. The country's political and economic instability further exacerbates these challenges, making it difficult for both local and international investors to commit to large-scale solar projects [10]. Additionally, the existing energy infrastructure, primarily designed for centralized power generation, poses significant integration challenges for distributed solar energy systems [5]. Strategically addressing these obstacles is essential to unlocking the full potential of PV solar energy in Myanmar.

1.4 Research Focus and Rationale

This paper aims to explore the strategic development of PV solar energy in Myanmar through a dual approach, combining Grounded Theory and SWOT analysis. Grounded Theory, a qualitative research method, is employed to uncover the underlying themes and patterns related to public perception, policy challenges, and technological adoption of PV solar energy in Myanmar [11]. This method facilitates an in-depth understanding of the social, economic, and political factors influencing solar energy adoption, providing valuable insights into the barriers and opportunities within the current energy landscape [12]. SWOT analysis, on the other hand, systematically evaluates the strengths, weaknesses, opportunities, and threats associated with the development of PV solar energy in Myanmar [13]. By identifying the internal and external factors that can impact the success of solar energy projects, SWOT analysis offers a comprehensive framework for strategic planning and decision-making. The combination of Grounded Theory and SWOT analysis presents a holistic approach to understanding the complex dynamics within the energy sector, enabling the development of actionable strategies to promote the adoption of PV solar technology in Myanmar.

1.5 Significance of the Study

The importance of this study lies in its potential to contribute to the expanding body of knowledge on renewable energy development in emerging economies, with a particular focus on Myanmar. Although extensive research exists on the adoption of PV solar energy in developed countries, there is a relative lack of studies that address the distinct challenges and opportunities encountered by developing nations. By applying Grounded Theory and SWOT analysis, this research provides a nuanced understanding of the factors that influence the adoption of solar energy in Myanmar, offering insights that can inform policy decisions, guide investment strategies, and support the broader goal of sustainable energy development.

Moreover, this study is timely given the increasing global emphasis on transitioning to renewable energy sources in response to climate change. Myanmar, as a signatory to the Paris Agreement, has committed to reducing its greenhouse gas emissions and increasing the share of renewable energy in its energy mix [14]. However, achieving these goals requires a concerted effort to overcome the barriers to solar energy adoption and leverage the opportunities presented by advancements in solar technology. This research not only highlights the current challenges but also provides practical recommendations for policymakers, investors, and other stakeholders to support the growth of the solar energy sector in Myanmar.

1.6 Structure of the Paper

The remainder of this paper is structured as follows: The next section provides a detailed overview of the research methodology, including the application of Grounded Theory and SWOT analysis in the context of this study. This is followed by a presentation of the findings from the Grounded Theory exploration, which identifies key themes related to public perception, policy challenges, and technological adoption of PV solar energy in Myanmar. The subsequent section presents the results of the SWOT analysis, highlighting the strengths, weaknesses, opportunities, and threats associated with PV solar development in the country.

The discussion section integrates the findings from the Grounded Theory exploration and SWOT analysis, providing a comprehensive analysis of the factors influencing the adoption of PV solar energy in Myanmar. This section also offers strategic recommendations for overcoming the identified challenges and leveraging the opportunities for sustainable energy development. Finally, the paper concludes with a summary of the key findings, implications for policy and practice, and suggestions for future research.

The development of PV solar energy in Myanmar represents a critical step towards achieving energy security, reducing carbon emissions, and fostering sustainable economic growth. However, the successful adoption of this technology requires a deep understanding of the social, economic, and political factors that influence its deployment. By applying Grounded Theory and SWOT analysis, this study provides valuable insights into the strategic considerations that must be addressed to unlock the potential of PV solar energy in Myanmar. The findings and recommendations presented in this paper aim to inform and guide stakeholders in their efforts to promote the growth of the solar energy sector and contribute to the broader goal of sustainable energy development in Myanmar.

2. METHODS

2.1 Research Design

This study employs a qualitative research design, combining Grounded Theory and SWOT analysis to explore the strategic development of photovoltaic (PV) solar energy in Myanmar. The research design is rooted in the need to understand the complex and multifaceted factors that influence the adoption and deployment of PV solar technology in a developing country context. The choice of Grounded Theory allows for the identification and development of theoretical insights from the data, while SWOT analysis provides a structured framework to assess the internal and external factors that impact the strategic planning of solar energy projects.

2.2 Grounded Theory Approach

Grounded Theory [12] is a systematic qualitative research methodology designed to generate theory from data. In this study, it is employed to explore the perceptions, experiences, and attitudes of stakeholders in Myanmar's PV solar sector. The research involves multiple stages of data collection, including in-depth interviews, site visits, and document analysis.

2.2.1 Data collection

Interviews: Semi-structured interviews were conducted with a diverse group of stakeholders, including policymakers, system operators, investors, developers, and representatives from local communities. The interviews were conducted from January 2023 to August 2024, each lasting between 30 to 60 minutes. These interviews aimed to gain a comprehensive understanding of the stakeholders' perspectives on the challenges and opportunities associated with PV solar energy in Myanmar.

Site Visits: To complement the interview data, site visits were conducted at several solar installations in Myanmar, including the Minbu, Thazi, Thapyaywa-1, Thapyaywa-3 solar plants, and the Mocha area (see Fig. 1). These visits provided firsthand insights into the operational challenges, technological issues, and environmental considerations related to PV solar deployment in the country.

Document Analysis: Relevant documents, including policy reports, regulatory frameworks, and previous studies on renewable energy in Myanmar, were reviewed to provide contextual background and support the analysis of interview and site visit data.

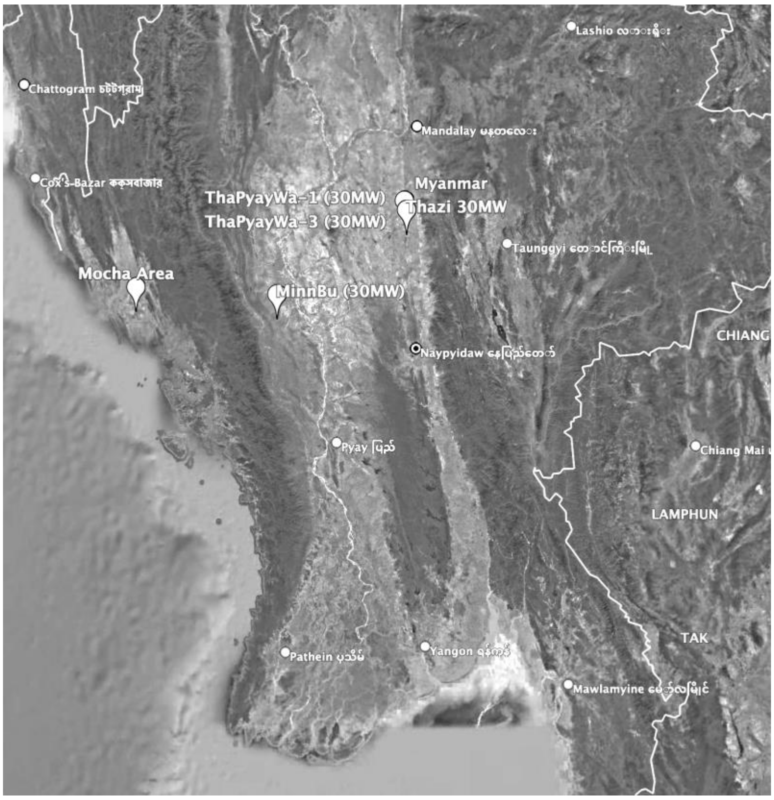

Fig. 1. Locations of site visits to solar installations and Mocha area

2.2.2 Data analysis

In this study, the qualitative data collected from the semi-structured interviews, site visits, and document analysis were analyzed manually, following the principles of Grounded Theory. Although qualitative analysis software such as NVivo is often used to facilitate data management and coding, a manual approach was chosen to allow for a more in-depth and nuanced engagement with the data. The analysis adhered to the principles of Grounded Theory, involving three key stages: open coding, axial coding, and selective coding [11,15].

Open Coding: Initial coding was conducted to identify key themes, concepts, and categories emerging from the data. This process involved line-by-line analysis of the transcripts to capture the nuances in stakeholders' responses [16].

Axial Coding: In this stage, the identified codes were organized into broader categories and subcategories, establishing relationships between different themes. This process helped refine the emerging theory by linking categories and identifying core concepts [15].

Selective Coding: Finally, the core categories were integrated into a coherent theoretical framework that explains the factors influencing the adoption of PV solar energy in Myanmar. This framework served as the foundation for the SWOT analysis conducted in the next stage of the research [12].

2.3 SWOT Analysis

A SWOT analysis of solar energy in Myanmar highlights both opportunities and challenges. Strengths include the country's favorable solar radiation and growing demand for energy, particularly in industrial zones. However, weaknesses such as high installation costs, limited financial incentives, and insufficient infrastructure hinder progress [1]. The growing interest in renewable energy in Southeast Asia presents opportunities for Myanmar, especially as regional players like Thailand and China invest heavily in solar technologies [7]. Additionally, studies have shown that Myanmar has significant solar energy potential, with solar development and applications being explored across various regions of the country [17]. Nonetheless, the uncertain political environment and lack of a net metering policy present significant threats to large-scale adoption [8].

2.4 Integration of Grounded Theory and SWOT Analysis

The final stage of the research involved integrating the findings from Grounded Theory and SWOT analysis to develop a comprehensive understanding of the strategic factors influencing PV solar energy adoption in Myanmar. This integrated approach allowed for the identification of key strategic priorities and recommendations for policymakers, investors, and other stakeholders to enhance the development of PV solar energy in the country.

2.5 Ethical Considerations

The study adhered to ethical guidelines throughout the research process. Informed consent was obtained from all interview participants, and confidentiality was maintained by anonymizing the data. The research was conducted with sensitivity to the cultural and political context of Myanmar, ensuring that the findings are presented in a manner that respects the perspectives and experiences of the participants.

3. RESULTS

3.1 Grounded Theory Findings

The application of Grounded Theory in this study revealed several key themes that provide insight into the factors influencing the adoption and development of photovoltaic (PV) solar energy in Myanmar. The themes identified through open, axial, and selective coding processes are summarized in Table 1.

The followings summarize the insights from key stakeholder groups, outlining their concerns, the opportunities they identified, and their suggested policy interventions to accelerate solar adoption.

Policymakers: Site visits revealed gaps in the implementation of renewable energy policies, despite national commitments. Literature review confirmed the potential for distributed solar systems to enhance energy security, aligning with policymakers' goals to expand renewable capacity.

Table 1. Summary of key themes from grounded theory findings

Stakeholders group	Key themes	Opportunities identified	Policy recommendations
Policymakers	-Integration of renewable energy into national infrastructure -Mandatory rooftop solar systems	-Expanding renewable capacity through decentralized systems	-Develop clearer, consistent policies -Provide incentives for rooftop solar and distributed generation
Investors	-High upfront costs and regulatory uncertainty -Compensation disparities for grid feed-in	-Cost savings and increased energy independence through PV installations	-Introduce financial incentives -Regulatory flexibility for large-scale solar investments
Community Members (Rural)	-Community resilience through PV solar -Technological adaptation in agriculture	-Enhanced agricultural productivity through solar water pumps	-Support community-based solar initiatives with financial incentives and technical assistance
System Operators	- Challenges in solar penetration and grid capacity management -Role of battery storage	-Improved grid resilience through solar-battery hybrid systems	-Establish guidelines for integrating PV solar with energy storage systems
Industrial Operators	-Regulatory rigidity and need for flexibility - Challenges with integrating PV in industry	-Viable business models for solar adoption in industrial operations	- Reform industrial energy policies to promote PV solar and offer compensation for excess electricity generation

Investors: During site visits, investment security and regulatory uncertainty were identified as key barriers. Literature review supported this, highlighting the need for stable regulatory frameworks and financial models that incentivize large-scale PV solar investment.

Community Members (Rural): Site visits showed practical examples of solar water pumps and small-scale PV systems improving agricultural productivity. Literature review pointed to similar opportunities for off-grid solutions that could provide rural communities with enhanced energy access.

System Operators: Both site visits and literature review emphasized the critical role of battery storage in maintaining grid stability as solar penetration increases. This aligns with operator concerns about managing solar capacity while maintaining grid resilience.

Industrial Operators: Findings from site visits to industrial zones revealed regulatory barriers to the flexible use of PV solar in industrial settings. Literature review supports the need for policy reform to introduce net metering and compensation mechanisms for excess electricity generation, enabling industrial-scale adoption.

3.1.1 Public perception and awareness

A significant theme that emerged from the data is the high level of public awareness about PV solar energy in Myanmar. The interviews revealed that most stakeholders, including local communities, are aware of the benefits of solar energy, particularly in reducing electricity costs and contributing to environmental sustainability. However, despite this awareness, there is a considerable gap between knowledge and action, with many stakeholders expressing skepticism about the feasibility and reliability of solar technology, particularly in rural areas where access to stable energy remains a challenge.

3.1.2 Policy and regulatory challenges

The analysis identified policy and regulatory barriers as a major impediment to the widespread adoption of PV solar energy in Myanmar. Stakeholders pointed out that while the government has introduced policies to promote renewable energy, these policies are often inconsistent and lack clear guidelines for implementation. Moreover, the regulatory environment is perceived as complex and cumbersome, with lengthy approval processes and unclear regulations regarding land acquisition and grid connection. These challenges have deterred both local and international investors, slowing down the growth of the solar sector.

3.1.3 Economic and financial constraints

Economic barriers, particularly the high initial costs of solar installations, were frequently mentioned as a significant challenge. The lack of accessible financing options and government subsidies has made it difficult for households and businesses to invest in solar technology. Additionally, stakeholders expressed concerns about the long payback period for solar investments, which further discourages adoption. The data also highlighted the limited availability of local expertise in solar technology, leading to higher costs for installation and maintenance, as well as dependency on foreign contractors.

3.1.4 Technological and infrastructural issues

Technological and infrastructural challenges also emerged as critical barriers to the development of PV solar energy in Myanmar. The existing energy infrastructure, which is predominantly designed for centralized power generation, poses significant difficulties for the integration of distributed solar energy systems. Stakeholders reported frequent technical issues related to grid stability and energy storage, particularly in rural areas where the infrastructure is less developed. Additionally, the lack of local technical expertise in maintaining and operating solar installations was highlighted as a persistent challenge.

The Grounded Theory findings highlight key challenges and opportunities in the adoption of PV solar energy in Myanmar. Stakeholders, including policymakers, investors, community members, system operators, and industrial operators, identified significant barriers such as high upfront costs, regulatory uncertainty, and the need for technological improvements like battery storage. Despite these challenges, there are clear opportunities for decentralized solar systems to enhance energy security and agricultural productivity, especially with policy reforms and financial incentives. Addressing these barriers through coherent policies, incentives, and community-based solar initiatives will be critical to accelerating solar adoption in the country.

3.2 Synthesizing Grounded Theory Insights with SWOT Analysis

The integration of Grounded Theory findings with SWOT analysis offers a clear understanding of the factors shaping PV solar energy development in Myanmar. Stakeholder interviews revealed key themes closely aligned with the SWOT analysis of strengths, weaknesses, opportunities, and threats.

Strengths: Grounded Theory highlighted Myanmar's abundant solar resources as a major asset, with policymakers and system operators recognizing solar energy’s potential to enhance energy security. Growing public acceptance and investor interest in renewable energy were also notable strengths, corresponding with the SWOT analysis, which identified solar resources and public awareness as key growth drivers.

Weaknesses: High upfront costs and regulatory barriers were identified as primary weaknesses. Investors and industrial operators voiced concerns over the lack of financial incentives and regulatory complexity. Similarly, system operators emphasized the need for infrastructure improvements to support distributed solar systems, reflecting the SWOT findings on installation costs, regulatory challenges, and infrastructure limitations.

Opportunities: Grounded Theory revealed opportunities in international partnerships and technological innovations, such as solar-battery hybrids. Expanding solar access to rural areas was a priority for policymakers and investors, aligning with the SWOT analysis, which highlighted international collaboration and technological advances as key growth opportunities.

Threats: Political instability and regulatory uncertainty were cited as significant threats. Concerns about the reliability of solar systems in underdeveloped regions were echoed by investors and community members, aligning with the SWOT analysis, which identified political risks, financial instability, and the absence of net metering policies as barriers to large-scale solar adoption.

This synthesis of Grounded Theory and SWOT analysis provides a strategic framework for addressing challenges and seizing opportunities in Myanmar’s solar energy development. Targeted interventions such as regulatory reform,

Table 2. SWOT analysis of PV solar energy development in Myanmar

Strength	Weakness
1. Renewable Energy Potential 2. Government Support 3. Public Acceptance 4. Economic Viability 5. Technological Advancements 6. Environmental Benefits 7. Community Resilience	1. Regulatory Hurdles 2. Requirement for large land areas 3. Land tenure issues 4. High Upfront Costs 5. Lack of Awareness and Expertise 6. Cost Concerns 7. Technical Expertise
Opportunity	**Threat**
1. Addressing Power Outages 2. Technological Innovation 3. Stakeholder Collaboration and Policy Advocacy 4. International Collaboration 5. Policy Reforms 6. Public Awareness 7. Expansion in Rural Areas 8. Market Development 9. Market Incentives and Expansion 10. Business-to-business (B2B) model 11. Institutional Capacity Building 12. Tariff Reform 2024	1. Political Instability 2. Regulatory Complexity 3. Community Resistance 4. Environmental Concerns 5. Financial Risk 6. Absence of Net Metering Policy 7. Dissatisfaction with Metering System 8. Land Acquisition Challenges 9. Overdevelopment Risks 10. Grid Integration Challenges 11. Economic and Financial Challenges 12. Natural Disasters 13. Competing Energy Sources 14. Technological Barriers

financial incentives, and technological advancements, are essential to overcoming barriers and maximizing Myanmar's solar potential.

3.3 SWOT Analysis Results

The SWOT analysis provided a structured evaluation of the internal and external factors affecting the development of PV solar energy in Myanmar. The findings from this analysis are summarized in Table 2.

3.3.1 Strengths

The SWOT analysis identified several strengths that could support the successful deployment of PV solar energy in Myanmar:

1) **Renewable Energy Potential:** Myanmar's abundant solar resources present a significant opportunity for the deployment of PV solar energy.
2) **Government Support:** There is increasing support from the government for renewable energy initiatives, which is critical for the growth of the solar sector.
3) **Public Acceptance:** Growing awareness and acceptance of renewable energy among the public are positive drivers for solar energy adoption.
4) **Economic Viability:** The declining costs of solar technology, combined with its long-term economic benefits, enhance its viability as a sustainable energy solution.
5) **Technological Advancements:** Ongoing advancements in solar technology improve efficiency and reduce costs, making it more attractive for deployment.
6) **Environmental Benefits:** PV solar energy is a clean, renewable energy source that contributes to environmental sustainability by reducing carbon emissions.
7) **Community Resilience:** The deployment of solar energy can enhance community resilience by providing reliable access to electricity, especially in remote areas.

3.3.2 Weaknesses

Despite its strengths, the analysis also identified several weaknesses that pose challenges to the widespread adoption of PV solar energy in Myanmar:

1) **Regulatory Hurdles:** Complex and inconsistent regulatory frameworks create significant barriers to the implementation of solar projects.
2) **Requirement for Large Land Areas:** The need for large land areas for solar installations can be challenging,

particularly in regions with dense populations or valuable agricultural land.

3) **Land Tenure Issues:** Unclear or disputed land ownership often hinders the development of solar projects.
4) **High Upfront Costs:** The high initial investment required for solar installations remains a major obstacle for potential adopters.
5) **Lack of Awareness and Expertise:** Limited local expertise in solar technology and insufficient public awareness about its benefits slow down adoption rates.
6) **Cost Concerns:** Despite the long-term savings, concerns about high initial costs and ongoing maintenance expenses deter many from investing in solar technology.
7) **Technical Expertise:** The shortage of skilled technicians and engineers needed to install, maintain, and operate solar installations increases dependency on foreign expertise and raises project costs.

3.3.3 Opportunities

The analysis highlighted numerous opportunities that could be leveraged to promote the growth of PV solar energy in Myanmar:

1) **Addressing Power Outages:** Solar energy offers a reliable solution to frequent power outages, improving energy security.
2) **Technological Innovation:** Advancements in solar technology present opportunities for more efficient and cost-effective solutions.
3) **Stakeholder Collaboration and Policy Advocacy:** Collaboration among stakeholders, including government, private sector, and NGOs, can drive policy advocacy and support for solar energy.
4) **International Collaboration:** Partnerships with international organizations can bring funding, technical expertise, and best practices to support solar energy development.
5) **Policy Reforms:** Ongoing reforms in the energy sector can create a more favorable environment for solar energy projects.
6) **Public Awareness:** Increasing public awareness campaigns can further drive the adoption of solar technology.
7) **Expansion in Rural Areas:** Significant potential exists for expanding solar energy to off-grid rural areas, improving access to electricity.
8) **Market Development:** The development of a robust solar market in Myanmar presents opportunities for business growth and job creation.
9) **Market Incentives and Expansion:** Providing market incentives can stimulate demand for solar technology and encourage investment.
10) **Business-to-Business (B2B) Model:** The B2B model offers opportunities for large-scale solar installations and corporate partnerships.
11) **Institutional Capacity Building:** Building institutional capacity to manage and support solar projects can enhance sustainability and project success.
12) **Tariff Reform 2024:** The 2024 electricity tariff reform introduces a cost-reflective pricing structure, which can attract investment in PV solar projects by providing a more predictable and stable financial environment. This reform is a key driver for expanding the solar sector, as it makes renewable energy projects more financially viable and attractive to both domestic and international investors.

3.3.4 Threats

Finally, the SWOT analysis identified several threats that could undermine the development of PV solar energy in Myanmar:

1) **Political Instability:** Political instability poses significant risks to the stability and predictability needed for long-term investments in solar energy.
2) **Regulatory Complexity:** The complexity and inconsistency of the regulatory environment can deter investors and slow down project implementation.
3) **Community Resistance:** In some areas, resistance from local communities due to concerns about land use or environmental impact can delay or halt solar projects.
4) **Environmental Concerns:** Concerns about land use, waste from old panels, and potential ecosystem disruption present challenges to solar energy deployment.
5) **Financial Risk:** Economic challenges, including currency fluctuations and limited access to capital, present financial risks for solar energy investments.
6) **Absence of Net Metering Policy:** The lack of a clear net metering policy makes it less attractive for businesses and households to invest in solar technology.

7) **Dissatisfaction with Metering System:** Issues with the existing metering system can lead to dissatisfaction among solar users, reducing the appeal of adopting solar energy.
8) **Land Acquisition Challenges:** Securing land for large-scale solar projects can be difficult due to ownership disputes and competing land uses.
9) **Overdevelopment Risks:** Rapid expansion of solar projects without proper planning can lead to overdevelopment and associated risks, such as oversupply and grid instability.
10) **Grid Integration Challenges:** Technical difficulties associated with integrating solar energy into the existing grid remain a significant challenge.
11) **Economic and Financial Challenges:** Broader economic issues, including inflation and financial instability, can impact the feasibility of solar projects.
12) **Natural Disasters:** Myanmar is prone to natural disasters such as cyclones and floods, which can damage solar installations and disrupt energy production.
13) **Competing Energy Sources:** The continued use and development of other energy sources, such as hydropower and natural gas, pose competition to solar energy.
14) **Technological Barriers:** Barriers related to the adoption of new technologies, such as storage solutions, can limit the effectiveness of solar energy systems.

4. DISCUSSION

The findings from Grounded Theory highlight a critical awareness gap between stakeholders' knowledge of PV solar energy and their willingness or ability to adopt it. Despite high awareness levels, particularly regarding the environmental and economic benefits of solar energy, there remains hesitation to invest in solar technology due to perceived financial risks, technological uncertainties, and regulatory barriers. These insights align with the weaknesses identified in the SWOT analysis, such as high initial costs, limited local expertise, and infrastructural challenges.

4.1 Financial Barriers and Solutions

One of the most critical barriers identified is the high initial cost of installation, compounded by the lack of accessible financing options. The SWOT analysis highlights these financial constraints as a significant weakness, deterring potential adopters despite the long-term economic benefits of solar technology. To overcome these financial barriers, concrete solutions from countries with similar challenges, such as India's KUSUM scheme, offer valuable insights. This initiative reduced the financial burden on farmers through subsidies and low-interest loans, which could be adapted in Myanmar to encourage both rural and urban adoption of solar technology [18]. Pay-as-you-go solar models, such as those implemented in Bangladesh’s IDCOL program, also demonstrate innovative financing solutions that reduce upfront costs [19].

4.2 Policy and Regulatory Challenges

The study underscores the need for more robust and consistent policy and regulatory frameworks to support the growth of PV solar energy in Myanmar. While government support exists, the regulatory environment is characterized by complexity and inconsistency, creating significant obstacles for investors and developers. Vietnam’s feed-in tariff policy provides an example of how stable and attractive regulatory frameworks can drive solar investments [20]. Implementing similar feed-in tariffs, simplifying land acquisition procedures, facilitating grid connections, and introducing a net metering policy could significantly enhance the attractiveness of solar investments in Myanmar. These policy reforms, identified as opportunities in the SWOT analysis, are crucial for creating a more favorable environment for solar energy development.

4.3 Local Expertise and Technological Innovation

Another critical issue identified is the limited local expertise in solar technology, which increases dependency on foreign contractors and raises project costs. This lack of technical expertise, combined with Myanmar’s infrastructural inadequacies for integrating distributed solar energy, poses significant challenges. Building local capacity, as seen in Thailand’s One-Stop Service Model for renewable energy, can be a solution [21]. Investing in training programs, educational initiatives, and partnerships with technical institutes could create a skilled workforce capable of installing and maintaining solar installations. Moreover, the integration of solar-battery hybrid systems, as indicated in the

SWOT analysis, presents opportunities for enhancing grid stability and improving the efficiency of solar energy use.

4.4 Opportunities Through International Collaboration

The study also highlights several opportunities for international collaboration and stakeholder partnerships that could promote the growth of PV solar energy in Myanmar. Partnerships with international organizations, like those in Bangladesh's IDCOL program, can provide funding, technical expertise, and capacity building [19]. Myanmar should actively engage with international partners to support the growth of its solar energy sector. Additionally, targeted public awareness campaigns could drive the adoption of solar technology in rural areas, where energy access remains limited.

4.5 Mitigating Threats

The study also identifies threats that could undermine the development of PV solar energy in Myanmar, including political instability, regulatory complexity, and financial risks. These threats, if not adequately managed, could deter investment and slow down the implementation of solar projects. To mitigate these risks, Myanmar should focus on creating a stable and predictable investment environment, as seen in successful international projects. This includes measures to protect investments from political risks, ensuring that economic policies support renewable energy growth, and addressing land acquisition challenges through transparent processes. Furthermore, addressing technological barriers, such as storage solutions and grid integration challenges, is critical for the long-term success of solar energy projects in the country.

4.6 Strategic Recommendations

Based on the findings and discussion, the following strategic recommendations are proposed to enhance the development of PV solar energy in Myanmar:

1) **Develop and Implement Financial Mechanisms:** Introduce subsidies, low-interest loans, and innovative financing models to reduce the financial barriers to solar adoption.
2) **Strengthen Policy and Regulatory Frameworks:** Streamline regulatory processes, provide clear guidelines, and create a predictable policy environment to attract investment in solar energy.
3) **Build Local Expertise and Capacity:** Invest in training programs and educational initiatives to develop local expertise in solar technology and reduce dependency on foreign contractors.
4) **Leverage International Collaboration:** Actively seek partnerships with international organizations and private sector partners to bring in the latest solar technologies, technical expertise, and funding.
5) **Mitigate Political and Economic Risks:** Implement measures to protect investments and ensure that economic policies support the growth of the renewable energy sector.
6) **Promote Social Acceptance and Behavioral Change:** Engage communities through targeted awareness campaigns, education programs, and pilot projects to build trust in solar technology and drive adoption.

5. CONCLUSION

The exploration of photovoltaic (PV) solar energy development in Myanmar, using Grounded Theory and SWOT analysis, provides a comprehensive understanding of the factors influencing the adoption of this renewable energy. The study highlights the significant potential of PV solar to enhance energy security, reduce reliance on fossil fuels, and contribute to environmental sustainability.

Strengths like Myanmar's abundant solar resources, public acceptance, and government support indicate a solid foundation for solar energy development. However, challenges such as high upfront costs, regulatory hurdles, and land requirements must be addressed to unlock this potential. Opportunities include rural solar expansion, technological innovation, and international collaboration; all key to overcoming these barriers.

The study also identifies threats like political instability, regulatory complexity, and financial risks, which require careful management through strategic planning and policy interventions. Integrating Grounded Theory into the SWOT analysis provided critical insights into stakeholders' concerns, offering a nuanced understanding of the social, economic, and political dynamics influencing solar adoption.

Moving forward, collaboration among government agencies, investors, and NGOs is essential to create an enabling environment for solar energy development. Strategic recommendations include implementing financial mechanisms, establishing consistent regulatory frameworks, and fostering international partnerships. With the right interventions, Myanmar can transform its energy landscape, providing sustainable energy to underserved regions and contributing to global climate goals.

In conclusion, while challenges remain, the potential benefits of PV solar in Myanmar are immense. Strategic interventions and collaboration can harness this potential, positioning Myanmar as a renewable energy leader in Southeast Asia, supporting a resilient and sustainable energy future.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby declare that generative AI technology, specifically ChatGPT, was utilized for grammar and language usage review during the preparation of this manuscript.

ETHICAL APPROVAL AND CONSENT

This study was conducted in accordance with the ethical guidelines of the International Leadership University Myanmar. Ethical approval was obtained from the Institutional Review Board of International Leadership University Myanmar, and informed consent was acquired from all participants prior to their involvement in the study.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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