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Analysis of Stakeholders in Off-Grid Power Generation and Research on Business Models in Laos

Chattouphonh Nakhavith[1,2] and Hung Dechun[1]

1. Business School of Hohai University, Nanjing, China

2. Department DG of DEEP, MEM, Lao PDR

Abstract: This study explores off-grid power generation business models in the Lao People's Democratic Republic (Lao PDR), with the objective of identifying viable pathways to expand energy access in rural and underserved regions. The research aims to analyze and evaluate various business models in terms of their technical, economic, and social viability within the unique geographic and policy context of Lao PDR. There are two level of the research objectives: High Level Objectives (HLO) and Concreted Research Objectives (CRO). For HLO is that an appropriated off-grid power generation business model for Laos supports the Lao PDR Government's commitment to promote an inclusive green growth development agenda that ensures lowered GHG emissions and increased energy efficiency. The Lao PDR National Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) notes the country's ambitious plans to lower energy consumption and reduce GHG emissions. While the CRO are focused on learning strategies, regulation and practical lessons from other countries the ASEAN region on the off-grid development and business model. To analyze and investigate the environmental strategy of business model under external and internal context and related and considered factors. And finally, this is to conclude and recommend the off-grid power generation business model as the research conclusion, which will become a support mechanism for the companies to operate consistently over many years into the future according to ambitious goal for supplying modern and save energy for rural families by 2030

Key words: Off-grid power generation, business mode, Lao PDR, renewable energy, energy access, green growth, climate change mitigation, stakeholder analysis.

1. Introduction

1.1 Energy Development Context in Laos

Lao PDR (Lao People's Democratic Republic), is a landlocked Southeast Asian nation rich in natural resources, particularly water resources, which have positioned it as a regional leader in hydropower production. Today, the transition to electricity for income generation has been faster than before. But the Lao PDR Renewable Energy Development Strategy states a commitment to reduce energy consumption by 10 percent by 2030.[1]

In addition, the country's National Strategy on Climate Change sets a goal to achieve low-carbon economic growth. Laos is often referred to as the "Battery of Southeast Asia" due to its vast hydropower potential. It is high priority as outlined in the 8th NSEDP (National Socio-Economic Development Plan), the National Strategy, and the Vision 2030. The Mekong River and its tributaries provide an estimated hydropower capacity of 26,000 MW, of which only about one-third has been developed. Hydropower projects have played a central role in the country's energy strategy, both for domestic energy needs and electricity exports.

In the regards of Energy Development Plan, the Off-Grid Power Generation in Lao PDR is very much important and plays a crucial role in the development of Lao PDR, given its geography, economic conditions, and energy access challenges. There are many rural communities in Laos that are not connected to the national grid due to challenging terrain and high

Corresponding author: Chattouphonh Nakhavith, Ph.D. student, Business School of Hohai University.

[1] Vision 2030, MEM-Lao PDR, December 2017.

infrastructure costs. Off-grid solutions provide electricity to these remote villages. The Off-Grid Development will be reducing reliance on centralized power plants and importing fossil fuels enhances national energy security, especially in areas with unstable grid supply.

It will create and provide the rural communities with access to safe and reliable electricity in order to create and develop their businesses, agriculture, and local industries to thrive, contributing to economic development and improving livelihoods. The Off-Grid renewable energy sources (solar, wind, hydro, biomass) reduce dependence on diesel generators, lowering greenhouse gas emissions and deforestation and also support for social services (Education and Healthcare): schools, clinics, and hospitals need electricity for lighting, refrigeration (for vaccines and medicines), and digital education tools.

The government of Laos has recognized the importance of renewable energy in achieving sustainable development and addressing energy security, economic growth, and environmental challenges. To this end, Lao PDR plans to make the progress on its net zero 2050 commitment by updating its National Power Development Plan and RE Strategy.[2]

1.2 Key Targets and Goals

The National Strategy outlines specific renewable energy targets to be achieved by 2030:

(1) Solar Energy: Develop at least 1,000 MW of solar PV (photovoltaic) capacity to leverage the country's high solar radiation potential.

(2) Wind Energy: Exploit wind resources in the southern and eastern regions of Laos, targeting a capacity of 1,500 MW.

(3) Biomass and Bioenergy: Promote the use of agricultural and forestry residues, as well as municipal waste, with a target of 500 MW capacity.

(4) Small Hydropower: Support small-scale hydropower projects (less than 15 MW) to complement larger hydropower plants, especially for off-grid electrification.

(5) Biofuels: Increase biofuel production to meet 10% of the country's transportation fuel demand by 2030.

1.3 Objectives of the Strategy

The National Strategy on Renewable Energy Development sets ambitious goals for the adoption and expansion of renewable energy technologies. The main objectives include:

(1) Diversifying Energy Sources: Reduce dependence on hydropower by increasing the share of solar, wind, biomass, and bioenergy in the national energy mix.

(2) Promoting Energy Security: Strengthen the energy sector's resilience to external shocks, including climate variability, by developing reliable and locally sourced renewable energy.

(3) Encouraging Sustainable Development: Minimize the environmental and social impacts associated with large-scale hydropower projects and fossil fuels.

(4) Expanding Rural Electrification: Ensure energy access in remote and underserved areas using decentralized renewable energy systems.

(5) Contributing to Regional Commitments: Support regional and international climate goals, including the ASEAN target of achieving 23% renewable energy in the total primary energy supply by 2025.

The government has introduced several policy measures and initiatives to support the strategy's implementation: incentives for private investment; decentralized energy systems; PPPs (public-private partnerships); capacity building and R&D; strengthening regulatory frameworks; implementation challenges.

[2] Renewable Energy Development Strategy in Lao PDR, October 2011.

Despite its ambitious vision, the implementation of the National Strategy on Renewable Energy Development faces several challenges:

(1) High Initial Costs: Renewable energy projects, particularly solar and wind, require significant upfront investment, which can be a barrier in a developing country like Laos.

(2) Limited Technical Expertise: The lack of skilled labor and technical expertise in renewable energy technologies hinders the rapid deployment of projects.

(3) Infrastructure Gaps: Inadequate transmission and distribution infrastructure pose obstacles to integrating renewable energy into the national grid.

(4) Policy and Institutional Coordination: Overlapping responsibilities among government agencies can lead to inefficiencies in policy implementation.

1.4 Opportunities for Growth: Off-Grid Power Generation Program

Lao PDR has made significant strides in rural electrification, but many remote areas remain dependent on off-grid power solutions. The off-grid power generation program plays a critical role in bridging the energy access gap, fostering economic development, and improving living standards. However, there are several issues and challenges that hinder the effectiveness of this program. The challenging points below are described in order to recommend all concerned parties for further improvement.[3]

1.4.1 Financing Strategies for Off-Grid Electrification

Off-grid power generation requires innovative and sustainable financing models to ensure scalability and long-term viability. PPPs have emerged as a key approach, blending government support with private sector expertise and investment. International development agencies and organizations, such as the World Bank and the ADB (Asian Development Bank), play a critical role in providing concessional loans, grants, and guarantees to de-risk private investments in rural energy projects.

Community-based financing mechanisms also hold promise, where local stakeholders co-finance projects through MFIs (microfinance institutions) or cooperative models, fostering a sense of ownership and accountability. Additionally, carbon credit markets and green bonds offer opportunities to generate supplementary revenue streams by capitalizing on the environmental benefits of renewable energy systems.

The strategy opens up significant opportunities for growth in Laos' renewable energy sector:

(1) Regional Energy Trade: Laos can position itself as a supplier of clean energy to neighboring countries by exporting solar, wind, and biomass-generated electricity.

(2) International Financing: The strategy aligns with global climate goals, making Laos eligible for climate finance and development assistance from international organizations such as the World Bank, ADB, and Green Climate Fund.

(3) Private Sector Involvement: Increased incentives and regulatory clarity are likely to attract more private investment, both domestic and international, into renewable energy projects.

(4) Technological Advancements: Partnerships with global renewable energy companies can bring advanced technologies to Laos, reducing costs and improving efficiency.

2. Research Implications

2.1 Theoretical Implications

This research topic has the potential to make several theoretical contributions to the fields of stakeholder theory, business model innovation, and energy development in the context of emerging economies. These implications included: expanding stakeholder roles; stakeholder collaboration in resource-constrained environments; power dynamics and local context;

[3] VIII-5Years Energy Development Plan (2016-2020) and IX-5Years Energy Development Plan (2021-2025), 24 June 2020.

contribution to business model theory; business models for energy access; sustainability-oriented business models; scalability and adaptability and others.

2.2 Practical Implications

The research has significant practical implications for stakeholders, policymakers, businesses, and communities involved in off-grid power generation and energy access initiatives in Laos. These implications are covered the aspects of: enhancing stakeholder collaboration; improved stakeholder coordination; building trust and social acceptance; strengthening PPPs; informing business model development.

2.2.1 Designing Sustainable Business Models

PAYG (pay-as-you-go) models can improve affordability for low-income households by enabling small, incremental payments for solar energy systems; Community-based models can empower local ownership and management of micro-grids, ensuring long-term sustainability; Cross-subsidy models can balance commercial viability with social equity by leveraging revenues from higher-income users to subsidize energy costs for poorer households; Scalability and Replicability: The research's findings offer actionable insights for scaling successful off-grid business models in other rural areas of Laos or similar developing countries. By identifying key success factors, stakeholders can replicate proven approaches while avoiding common pitfalls; Supporting Rural Electrification Efforts and Affordable and Reliable Energy: Practical strategies derived from the research, such as innovative financing mechanisms (e.g., microfinance or subsidies), can make off-grid power generation affordable and reliable for low-income households.[4]

3. Research Status at Home and Abroad

This section provides an overview of the current status of research on off-grid models, focusing on Laos and relevant international experiences, which form the foundation for your research on stakeholders and business models in this context. The status of research on off-grid models, both in Laos and abroad, provides a solid foundation for analyzing stakeholder dynamics and developing sustainable business models. While Laos has made progress in exploring technical solutions and policy frameworks, significant opportunities remain to address gaps in stakeholder collaboration and innovative business models. Insights from international experiences can guide these efforts, ensuring that off-grid power generation contributes meaningfully to Laos' energy and development goals.

3.1 Status of Research on Off-Grid Models in Laos and Abroad

3.1.1 Status of Research in Laos

(1) Off-Grid Energy Landscape

Research on off-grid energy systems in Laos has predominantly focused on renewable energy sources, such as solar PV, small hydropower, wind, biomass and bioenergy. The Lao government's renewable energy strategy, which aims for a significant increase in off-grid energy adoption, has attracted both academic and practical interest in the field. Key areas of focus include: technical feasibility; policy and governance; community engagement**;** challenges.

(2) Gaps in Research

Despite these efforts, gaps remain in understanding the interplay between stakeholders including government bodies, private companies, NGOs (nongovernmental organizations), and local communities and the development of sustainable business models tailored to Laos' socio-economic context. This gap underscores the need for further research into stakeholder dynamics and innovative business models to scale off-grid adoption.

3.1.2 Status of Research Abroad

(1) Technological Innovations

[4] NREL: Technical Report on Business Models to Accelerate the Utilization of Energy distributed Resources, TP-6A20-79549 November 2021.

Globally, off-grid systems have benefited from technological advancements, particularly in solar PV, battery storage, and hybrid systems. Countries in Sub-Saharan Africa and South Asia have implemented off-grid models with varying degrees of success, offering valuable lessons for Laos: SHS (solar home systems); mini-grids; IoT (internet of things) applications; business models; PAYG; PPPs; community-owned models; stakeholder analysis and others.

However, the unique socio-economic and geographical context of Laos necessitates localized research to adapt these lessons effectively.

3.2 Factors Considering for Off-Grid Development in Laos

Off-grid power generation is crucial for achieving universal energy access in Laos, particularly in rural and remote areas where extending the national grid is technically challenging and economically unviable. These factors can be categorized into technical, economic, social, environmental, and policy-related dimensions: geographic and demographic context; topographical challenges; population density; accessibility; energy demand and usage patterns (household energy needs, productive uses of energy, scalability, and others).

4. Research on the Relationship between Policy Regulation and Power Generation Entities

(1) Policy as a Guiding Framework for Power Generation

(2) Licensing, Permits, and Compliance

(3) Incentives and Subsidies

(4) Pricing and Tariff Structures

(5) Role in Off-Grid Power Generation

(6) Environmental and Social Regulations

(7) Governance and Institutional Support

(8) Challenges in Policy-Entity Relationships

(9) Feedback Loop: How Power Generation Entities Influence Policies

5. Literature Review: Analysis of Stakeholders in Off-Grid Power Generation and Business Models in Laos

5.1 Government and Regulatory Bodies

Governments play a crucial role in creating policies, providing incentives, and regulating off-grid energy systems. In many developing countries, including Laos, the government's role is essential in supporting off-grid electrification through national energy policies and frameworks [1]. The Lao government has initiated several policies to promote renewable energy, including solar and hydropower, to meet the electrification goals outlined in the country's development plans [1].

5.2 Private Sector and Investors

Private companies are key players in the development, installation, and maintenance of off-grid energy systems. These actors include ESCOs (energy service companies), technology providers, and financing institutions [2]. The financial sustainability of off-grid projects often depends on the ability of these actors to mobilize investment and create viable financial structures. In Laos, foreign investment in renewable energy, particularly solar power, is growing, but access to financing remains a challenge (ADB, 2021) [2].

5.3 Local Communities and Consumers

Local communities are central to the success of off-grid projects. Their participation in the decision-making process, as well as their acceptance of new technologies, is critical. In Laos, rural populations are often the target of off-grid initiatives, where the electricity will not only provide basic lighting but also improve access to information and education, healthcare, and economic opportunities [3].

5.4 Regarding Advantaged Business Model for Laos

5.4.1 PAYG Model

The PAYG model is increasingly used in off-grid

solar systems, where consumers make payments for the energy used on a daily or monthly basis. This model has been widely adopted in Africa and is gaining traction in Southeast Asia, including Laos, due to its ability to make energy access affordable for low-income households. PAYG systems allow consumers to pay based on usage, with the option to purchase solar systems in small increments, thus reducing the initial investment required [4].

5.4.2 The Other Alternative Business Model: Hybrid Models (Government and Private Partnerships)

PPPs have been explored as a means to enhance the delivery of off-grid solutions. In this model, the government collaborates with private sector companies to deliver services, often with subsidies or incentives to lower costs for consumers. These hybrid models are particularly common in countries like Laos, where the government supports renewable energy projects but lacks the financial and technical capacity to implement them independently [5].

5.4.3 Microfinance and Credit Models

MFIs are critical to financing off-grid power systems for low-income populations. These institutions offer small loans or credit schemes to help rural communities invest in off-grid systems [6]. In Laos, microfinance models have been implemented for financing solar home systems and other small-scale renewable energy projects, facilitating access to energy for communities that otherwise could not afford it [6].

5.5 Conclusion

Reviewing the literature finally, all kinds of Off-Grid have the same applications as followings:

The significant application is in remote areas where access to the main power grid is limited or unreliable. These regions, particularly in developing countries, face challenges in obtaining electricity due to geographical constraints or the high costs associated with extending grid infrastructure. The self-sufficient energy systems, such as solar panels, wind turbines, and small-scale hydroelectric installations, provide a reliable and sustainable energy source for these communities.

The literature reveals that off-grid power generation offers significant potential for addressing energy access issues in Laos. The involvement of diverse stakeholders-governments, private sector companies, local communities, and NGOs is critical to the successful implementation of off-grid projects. However, challenges remain in terms of financing, policy frameworks, and local capacity building. Future research should focus on exploring the effectiveness of different business models in the Lao context and identifying strategies for overcoming barriers to investment and scaling up off-grid solutions.

6. Theoretical Basis

6.1 Institutional Theory

In the context of Laos, the alignment of government policies, international development goals, and local needs will be crucial in determining the sustainability of off-grid power generation solutions. Future research will be focused on the ways in which different business models are influenced by institutional factors and how institutional entrepreneurs can drive innovation in the energy sector.

Therefore, institutional theory provides valuable insights into the complex interplay of formal regulations, market practices, social norms, and cultural expectations that shape the development of off-grid power generation in Laos.

6.2 Business Models for Off-Grid Power Generation

In terms of business models, institutional theory suggests that the structure and sustainability of off-grid power generation models are shaped by both formal and informal institutions.

(1) Policy and Institutional Support for Business Models

Government policies, subsidies, and incentives are critical in determining the financial viability of off-grid

power systems. In Laos, the government's approach to promoting renewable energy through subsidies or tax exemptions can influence the profitability of business models like PAYG or leasing [2].

(2) Norms and Legitimacy of Business Models

For business models to succeed, they must be seen as legitimate by stakeholders. Norms surrounding payment systems, such as whether consumers prefer flexible payment plans (e.g., PAYG) or full ownership models (e.g., leasing), will impact the acceptance of business models. Legitimacy is often built through trust, transparency, and community engagement [7].

(3) Institutional Entrepreneurship

Institutional theory also highlights the role of "institutional entrepreneurs", individuals or organizations that actively work to change the institutional environment. In Laos, international development agencies, private companies, or NGOs may act as institutional entrepreneurs by introducing new business models.

7. Research Methodology and Technology Roadmap

7.1 Research Methods

This research employs a mixed-methods approach to provide a comprehensive understanding of the stakeholders involved in off-grid power generation in Laos and to analyze the various business models that can drive the sector's growth and sustainability. The mixed-methods approach combines qualitative and quantitative research strategies, enabling the study to capture both the depth of stakeholder interactions and the breadth of business model effectiveness.

7.2 Research Design

The research will follow a descriptive and exploratory design, as it seeks to explore the dynamics of stakeholders in the off-grid energy sector and the business models that operate within this context. The study aims to understand stakeholder behavior, relationships, and their roles in the development and implementation of off-grid power generation systems, while also investigating the business models that best support such initiatives in Laos.

(1) Data Collection Methods: A combination of qualitative and quantitative data collection methods will be used to ensure a comprehensive understanding of both the stakeholder dynamics and business model performance.

(2) Data Analysis Methods: The analysis will involve both qualitative and quantitative approaches to triangulate findings and provide a robust understanding of the research questions.

(3) Ethical Considerations: This research will adhere to ethical guidelines throughout the data collection and analysis process.

7.3 Technology Roadmap

7.3.1 Technology Roadmap

Technology roadmap for off-grid power generation in Laos will outline key milestones and technological innovations to be achieved throughout the research and development process.

- Short-Term (0-6 months): Stage 1: Consultation and Planning-Planning, Stakeholder Mapping, and Initial Data Collection.
- Medium-Term (6-12 months): Stage 2: Research Implementing Process-Data Collection, Business Model Evaluation, and Technological Analysis.
- Long-Term (12-18 months): Stage 3: Report on Business Models and Technology-Policy Recommendations, Stakeholder Engagement, and Final Roadmap.

7.3.2 Outputs

- Final report with a comprehensive roadmap for scaling off-grid energy in Laos.
- Policy recommendations and action plan for stakeholders involved in off-grid energy projects.
- Final presentation to key stakeholders with findings and suggested next steps.

8. Conclusion

The analysis of stakeholders in off-grid power

generation and the evaluation of business models in the context of Laos reveal several critical insights for advancing sustainable energy access in rural and underserved areas. Government and regulatory bodies play a foundational role by establishing enabling policies, offering subsidies, and creating institutional frameworks that support off-grid energy development. Private sector actors, including ESCOs and investors, are key to deploying technology, creating innovative financial models, and scaling up infrastructure, although access to capital remains a persistent challenge.

Local communities are central to the success of off-grid initiatives. Their participation, trust, and cultural acceptance are crucial for ensuring long-term viability. Business models such as PAYG, microfinance schemes, and hybrid PPPs have shown strong potential in the Lao context. These approaches lower the financial barrier for low-income households, making clean energy more accessible and equitable.

Importantly, the expansion of off-grid renewable energy systems particularly solar offers significant environmental benefits. These systems reduce dependency on diesel generators and traditional biomass, contributing to a decrease in greenhouse gas emissions and air pollution. This shift supports Laos's climate goals and aligns with global commitments to combat climate change. By promoting decentralized, clean energy solutions, off-grid models also enhance climate resilience in remote communities, which are often the most vulnerable to climate-related disruptions.

In conclusion, a multi-stakeholder, context-specific strategy that combines inclusive policy, innovative financing, community engagement, and a focus on clean energy is essential for the sustainable growth of off-grid power generation in Laos. Such an approach not only promotes social and economic development but also plays a vital role in achieving national and global environmental sustainability objectives.

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