Preliminary Problems Identification of Solar Home System Promotion Program in Lao PDR

Bouavone Chanthanileuth, Khamphone Nanthavong, and Zheng Jiliang

Abstract— *National electrification is among the key components in socio-economic development plan of Lao PDR to be removed from the Least Developed Countries list by 2020. In order to achieve the Millennium Development Goal, the Lao government has set up an ambitious target for residential electrification reaching 90% of households by 2020, of which 10% is by an off-grid approach. The Solar Home Systems (SHS) has been considered as the most appropriate solution for off-grid electrification in remote rural areas.*

This paper studied the experiences from the SHS promotion programs in Lao PDR, as well as to study relevant legal documents supporting rural electrification development in Lao PDR.

The research study found that inconsistency in institutional support and policy, inflexibility of delivery mechanism, improper system's standardization and management, inappropriate funding support, probably are among the most important issues in improvement of SHS promotion programs in off-grid areas. Besides, stronger participation of private sector is also a crucial factor for ensuring long term sustainability and reliable service. In this concern, the incentives may not be strong enough for attracting private sector involvement

Keywords— **Solar Home system, private sector involvement, delivery scheme, Off-grid electrification, hire-purchase, rental.**

1. INTRODUCTION

Lao PDR is located in the heart of South East Asia, sharing borders with Cambodia, China, Myanmar, Thailand and Vietnam. The land area is 269,800 km^2 and 70% of which is covered by forest. Of the estimated 6.5 million people in Laos, 85% of that population lives in rural areas. The government of Laos, one of the few remaining one-party communist states, began decentralizing control and encouraging private enterprise in 1986. GDP growth has remained approximately at a steady 7% which is driven by hydropower and mining. The national poverty line has been gradually decreased from 46.1% in 1993 to 26% of population in 2010. Despite this high growth rate, Laos remains a country with an underdeveloped infrastructure, particularly in rural areas. Therefore, national electrification has been considered among the most important issues in socio-economic development programs of Lao Government, to leave least developed countries status.

The government appears committed to raising the country's profile among investors by creating favorable environments for investment in the Lao PDR. The World Bank has declared that Laos' goal of graduating from the UN Development Program's list of least-developed countries by 2020 is achievable.

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2. SITE CONDITIONS

Rural Electrification Policy

In order to achieve development goals, rural electrification has been considered among the most important agendas of development programs of Lao Government. Electric power almost comes entirely from hydro-electric power plants. Electric Power imported from neighboring countries has solely been used for supplying strategic geographical border areas and remains a temporary measure while the national grid is being developed.

Rural electrification programs mainly promote grid connection. However, when grid extension is implemented in more remote rural areas, it becomes less economically viable. In response, the Lao Government has promoted off-grid options for rural electrification, mainly by small scale (micro) hydropower and solar home systems.

The off-grid areas were defined as those, which will not be able to reach grid by the year 2020. The Off-grid areas are typically characterized by difficult access, undeveloped infrastructure (road, communication, electricity and water supply, markets, etc), and rather low population density due to scattered inhabitation.

In order to emphasize the national electrification programs the Lao government has issued, since the late 1990s, several crucial legal documents such as the Electricity Law (1997, revised 2009), Power sector development plan (2001), National Renewable energy development strategy (2011), Rural Electrification Master Plan (2010); being drafted some decrees on small scale hydropower, biofuel, Solar energy, Other Biomass and alternative energy.

Electricity law [2] sets out the regime for the administration, production, transmission and distribution

of electricity, including export and import, through the use of productive natural resource potential to contribute to the implementation of the national socio-economic development plan and to upgrade liming standard of the people. The law allows individual or entities to develop hydropower in rural areas with install capacity less than 15 MW and obtaining approvals from relevant local authorities. The law encourages local investors participating in development of this sector.

Power System Development Plan [1] aims to maintain and expand an affordable, reliable and sustainable electricity supply within the country. Therefore, the purpose is to promote economic and social development; promote power generation for export to provide revenues to meet government development objectives; and ensure sustainability by developing and enhancing the legal and regulatory framework to effectively direct and facilitate power sector development; and reforming of institutional structural to clarify responsibilities and streamline administration.

The Renewable Energy Development Strategy [5] focuses on small power development for self sufficiency, grid connection, bio-fuel production and marketing, and development of other clean energies and emphasizes on promoting investment in energy productions from public and private sectors including local and foreign investors. By 2025 the Lao government aims to increase the share of renewable energies to 30% of the total energy consumption.

To reduce the import of fossil fuels, the government outlines a tentative vision to reach 10% of the total transport energy consumption per year from **bio-fuels** by 2025. In Lao PDR hydropower with capacity less than 15 MW is considered as small scale. Lao PDR has a potential for **small hydropower** development around 2,000 MW, of which, 650 MW is to be explored between 2010 and 2025. Lao PDR is located in a zone with relatively good solar irradiance. Solar PV home systems are serving as one of the electrification option in remote rural areas. Current SHS promotion program is aiming for installation of an additional 19,000 households in 331 villages of 11 provinces for the period 2010-2020. Besides that, the government also encourages development of large solar PV farm as an additional supply source for the grid. The government aims to sustain development of household and community scale **biogas** systems using animal and livestock wastes by 50,000 kg in 2025 to reduce the import of liquefied petroleum gas (LPG). Being a predominantly agriculture-based economy, Lao PDR generates substantial amount of wastes from agriculture and forest production and processing such as rice husks, corn cobs and wood wastes. **Biomass** cooking fuels are estimated to represent around 70% of the total energy consumption in Lao PDR. **Wind energy** can be potentially developed for large-scale grid-connection power generation and for hybrid systems providing energy services to rural and remote villages. The government aims to develop around 50 MW of wind power by 2025.

Rural Electrification Master Plan [3] imposes necessary approaches such as planning and monitoring of electrification by data management linked with geographical and visual information; national level standardized criteria of selection process of target villages and its electrification method with rational process using economic evaluation; and effective and sustainable financing plan based on optimum rural electrification plan. Rural electrification approaches are to improve the national electrification ratio from the current 70% to 90% by 2020 (80% by on-grid and 10% by off-grid) and minimize Micro Hydropower (MHP) due to the high cost of operations and maintenance while SHS shall be adopted as a temporary power source for villages in remote areas where grid extension is currently judged to be not feasible. The Off-grid component includes MHP, SHS/BCS, Pico-hydro, diesel generator and hybrid system.

Government Decrees on renewable energy and small hydropower are being drafted. Below is sample of the decrees:

Decree (draft) on solar energy development defines the principle, rules, and measures on the implementation, operation and supervision of solar energy business, to promote solar energy utilization including on-grid and off-grid options for increasing cleaner energy for self consumption and creating economically and technically viable promotion mechanism for solar technology development in Lao PDR.

On the other hand, decree (draft) on biomass gasification defines the principles, rules, and measures on the implementation, operation, regulation and supervision of biomass gasification business, to promote biomass-based power generation development including on-grid and off-grid options and to develop domestic small and medium size biomass gasification digester, for increasing cleaner energy for self consumption, effective agro-forestry-livestock wastes treatment aiming at creating economically and technically viable promotion mechanism for biomass technology in Lao PDR.

And finally, the decree (draft) on biogas production defines the principles, rules, and measures on the implementation, operation, regulation and supervision of biogas business, to promote biogas energy production including on-grid and off-grid options and to develop domestic small and medium size biogas digester, for increasing cleaning energy for self consumption, effective agro-forestry-livestock wastes treatment aiming at creating economically and technically viable promotion mechanism for biogas technology in Lao PDR.

Rural Electrification Status

Connection Ratio: The national mean connection ratio to the grid is about 80%. In case of off-grid SHS, the introduction ratio is said to be approximately 60%. Considering that present grid connection ratio would remain at 80% as well as the off-grid introduction ratio at 60%, the government could still not achieve the target electrification rate of 80% by grid and 10% by off-grid, even if all villages in the Lao PDR are covered by grid and off-grid electrification. Hence, it is requested to improve the connection ratio in electrified villages together with rural electrification implementation. The Power to the Poor (P2P) project under Rural

Electrification Plan (REP-1) has a record in improving the connection ratio from 81% up to 94% in the pilot project conducted in 2008. Expansion of P2P project to improve the national average connection ratio up to the level of 95% or more is necessary to achieve the electrification goal. As shown in Table1-1, 1-2 and Figure 1, in 2010 national electrification ratio throughout the country.

Off-Grid Options: Grid extension to remote areas of the country is economically not viable due to difficult mountainous landscape, plus sparse population density, low power demand, undeveloped infrastructure Therefore, Government turned to promote off-grid options rural electrification, which may included stand along PV Systems, small scale, hydropower, charging station, etc.

Table 1. Electricity Statistics

Year	Total amount		
	Districts	Villages	HH
1998	141	11,456	754,265
1999	141	11,058	768,142
2000	142	11,263	818,668
2001	142	11,231	866,277
2002	142	11,168	875,774
2003	142	10,866	883,355
2004	141	10,781	930,982
2005	139	10,473	1,000,350
2006	140	10,583	943,810
2007	140	9,630	959,094
2008	141	9,528	972,419
2009	141	9,063	1,026,012
2010	143	8,918	1,034,623

Table 2. Electricity Statistics

Year	**Electrified in 2010**					
	Districts	%	Villages	%	HH	%
1998	102	72	1,884	16	226,004	30
1999	109	77	2,507	23	254,610	33
2000	119	84	2,651	24	293,494	36
2001	116	82	2,811	25	303,690	35
2002	125	88	3,245	29	340,550	39
2003	128	90	3,776	35	379,109	43
2004	127	90	4,229	39	437,649	47
2005	132	95	4,510	43	483,133	48
2006	132	94	5,294	50	510,529	54
2007	136	97	4,940	51	566,110	59
2008	136	96	5,010	54	608,796	63
2009	137	97	5,811	64	714,613	70
2010	137	96	5,686	64	738,065	71

Source: Electricity Statistics Years Book 2010 of Lao PDR [4]

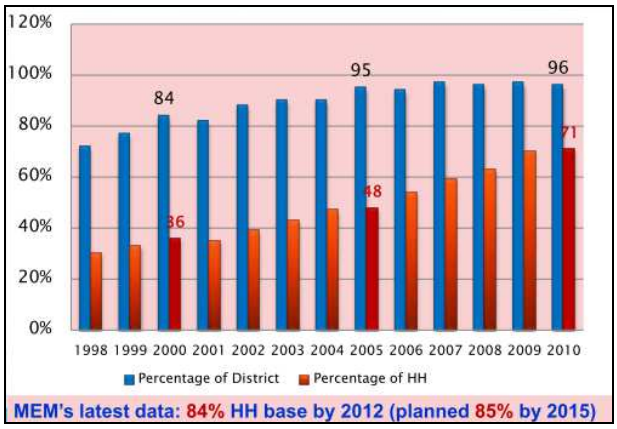

Fig. 1. Rural Electrification Status

Small scale Hydropower

Advantages*:* Hydropower electricity is generated from environmental friendly renewable natural resources, which help avoiding importing fossil oil products and hence, contribute to CO_2 emission reduction. Good for household and industrial use

Disadvantages*:* As a rule, SHP represents higher specific initial investment costs, comparing to larger HP. SHP strongly depends on local conditions, seasonal resource changes. Therefore, Energy generation highly depends on varying resource availability. Besides, Local communities lack of capacity to operate and maintain the system themselves.

Solar Home System/SHS

SHS is the main source in off-grid rural electrification while promotion of MHP is limited which due the high cost of investment and O&M difficulties. The promotion of SHS has become the most appropriate measure in power supply for villages in remote areas, where grid extension is currently judged to be not feasible.

Advantages*:* Relatively good solar irradiance (4-5 KWh/m^2/day), plus well known factors such as easy installation, low maintenance costs, long life equipment, as well as less environmental impacts remote rural villagers, while waiting for grid connection.

The Disadvantages of SHS are rather high equipment cost, short life of battery pack, limited power supply. In order to achieve reliable energy supply it will need to be combined with other energy sources and therefore, be a more costly solution.

Solar Battery Charging Station (SBCS)

This is a collective use system; the users have to pay for a rechargeable battery, limited appliance (mainly light) and a charging fee.

Advantages*:* This is a lesser cost option for rural people: users have ability to manage their energy usage and payment according to actually used energy only.

.**Disadvantage*:*** The common problems for SBCS are improper management approach that often leads to system failures. The environmental concern would be a disposal of numerous unused batteries.

Diesel Generator

Advantage: Perhaps this is the lowest initial investment option and can be a temporary solution until grid connection.

Disadvantages: High operation cost due to unstable fuel price and high fuel delivery costs to difficult-to-access remote areas, as well as environmental concerns of CO_2 emission.

Hybrid Systems

There are two hybrid systems which have been piloted in Lao PDR by NEDO[1] 1) SHP+PV in Oudomxay province and 2) SHP+PV+Capacitor in Phongsaly province [MEM-NEDO project].

Advantages*:* More reliable power supply and use of clean local resources as much as possible.

Disadvantages*:* High system costs.

Overal observation on off-grid Rural electrification programs in Lao PDR:

- Almost all micro hydropower installations (around 40 sites with capacity less than 100 MW) completely failed.
- SBCS could not find sustainable application, as well as diesel generator approach.
- SHS promotion can be considered as the most successful off-grid electricity installation option in Lao PDR.

Solar Home Promotion Programs in Laos PDR

The SHS program was initiated under the Southern Provinces Rural Electrification Project (1998-2004) and originally implemented by Electricite Du Laos (EDL). In February 2001, the responsibility of SHS program was then transferred to Ministry of Energy and Mines (MEM). The Off-Grid Promotion Support Office (OPS) was established within the Department of Electricity of MEM. In March 2001, MEM's Power Sector Policy Statement established the policy and regulatory mandate for Provincial Energy Service Companies (PESCOs) as intermediary entities to plan, help organize and install and then provide ongoing support to off-grid schemes in rural areas of the Lao PDR.

Up to 2010, totally 16,247 SHS of capacity between 20-50 Wp have been installed in 16 provinces (447 villages) of Lao PDR by various programs such as TRI's solar PV demonstration projects (1997-2001) under Technology Research Institute; MEM-JICA solar PV pilot projects (1998-2001) and MEM-WB Hire-purchase projects (1999-2004) owned by the Ministry of Energy and Mine; and Sunlabob-InWent pilot projects on Rental PV systems (since 2003) invested by private investor [8].

Currently four delivery models of stand-alone SHS have been carried out in the country: donation, cash sales, rental system and hire-purchase.

- **Rental system** is carried by Sanlabob co., which established in 2001. The company rents the hardware (equipment) to villagers and collects the fee.

  Management mechanism: In additional situation, if systems work properly, users pay monthly rent. The Village Electricity Committee (VEC) is able to transfer tariffs to the rental company and then receive margins. The rental company receives money to pay for the loan plus interest and receives income.

  Advantages: Users pay for used electricity only, equipment remains property of Rental Company. Service reliability is ensured by an established franchise with high quality equipment installed to ensure sustainability. The systems are installed and maintained by the hardware company's skilled technicians. On the other hand, the Energy Service Company (ESCO) has strong incentive to keep the system in good working conditions. And the flexibility of this system is such that the users are not required to do maintenance work or spare part replacement; this makes it an affordable choice.

  ***Disadvantages*:** High rental cost. In order to reduce service costs in remote rural areas, the rental company may install high quality and reliable equipment, installation by company qualified technicians, and therefore, rental costs will be rather high, and unaffordable for majority of rural people.

- **MEM-WB Hire-purchased model**: villagers choose a range of solar PV panel sizes, then lease the system and make the payment over a certain period (5 or 10 years) and after that the system becomes their property. Installation and maintenance of the system are carried by village energy manager (VEM), who got trained by the project counterparts and service is undertaken ESCO, which was set up by the project [9].

  Management mechanism: If system work properly, users pay monthly payment and then village energy manager (VEM) can make repayment to ESCO and get operational rebates. Therefore, ESCO is able to transfer money to OPS and can receive operational rebates.

  Advantages: the users own the equipment after repayment period is complete. Lower repayment rate is due to subsidy by the project. Well-designed financial incentives for planning, delivery, training and operational rebates and prospective ownership are available due to Soft Loan support.

  Disadvantages: Based on the information, the users pay for spare parts and installation fee and the available service is unreliable. The low profit business is unattractive for businesses and entrepreneurs. There are at times improper installation and servicing by unskilled technicians. And lastly, low quality equipment usually installed

[1] **NEDO:** New Energy and Industrial Technology Development Organization

to avoid high repayment for the system costs.

Lesson learned from SHS programs in Lao PDR

This paper emphasizes how to optimize SHS program management in Lao PDR to provide reliable and sustainable electricity supply by using costly technologies with affordable pricing for villagers with limited financial resources in isolate rural areas. Further studies on the application of an appropriate approach, tools and consistent support mechanisms from funding agencies or relevant organizations to encourage involvement from private initiatives into the business needs to be observed.

- ***TRI's solar PV demonstration projects (BCS and SH-BCS)***

  BCS: Villagers are responsible for the maintenance and replacement of their equipment. The collected fees are used for systems maintenance, spare parts replacement and to pay village technician salary. One key-house manager is required.
  SH-BCS: User's convenience is closer to house users, flexible charging process, lower capital cost. Complex management scheme: deal with many key-house managers. It is difficult to keep service standard as high as for all systems.
  It was observed that detailed management and cost recovery scheme was not worked out; lack of follow up activities and monitoring capacity; lack of management skills and funding support. As result, almost all of installed systems failed or have been evacuated due to grid connection.

- ***MEM-JICA solar PV pilot projects (SHS and BCS)***

  The project has shown that people in rural areas accepted the PV systems and demand is high; Initial payment and monthly fees are affordable for villagers; the setting reasonable market prices is necessary to promote the system; VEC plays a vital role in system management. Qualified VEC is very important; people's participation, capacity building and cost recovery are main points to sustainable operation; Standard system configuration, selecting system part and replacement of parts are main components to be addressed; Competency and incentive of local office of MEM to cope with system's monitoring and support for long term repayment period (15-20 years); Good for users who prefer low repayment, but, the projects need full long-term subsidies in the form of grants, which is not always available.

- ***MEM-WB hire-purchase projects (SHS, VH and GS)***

  For SHS [10], users purchase the equipment and are motivated to maintain its condition. The VEM and ESCO receive a portion of each user's monthly payment called "***operational rebates***", only if the users' payment is actually made. It is a strong incentive for VEM and ESCO to maintain the systems functionality properly in order to get the rebates. OPS does not approve plans for installation in new villages, if the ESCO is not matching an average repayment rate of above 95% from its entitled villages. Poor service of ESCO will skip its business.

- ***Sunlabob-InWent's pilot projects on Renting PV systems***

  The project was launched in cooperation between Sunlabob Co., LTD and InWent-Capacity building International (Germany), with consulting support by Viltec (Switzerland). The project was to prove that the rental mechanism within selective areas such as those along the national road, national borderlines and densely populated areas, where people normally have relatively high income and many belong to future grid expansion. The project involves many parties: government authorities, funding agency, rental company (hardware company), training company and village committee (VEC). The delivery model economically is not suitable for major rural population in remote areas due to high rental fee.

3. DISCUSSIONS

The issue reviewed in site conditions section of the right delivery model is the most critical. Cash sales model appears the least likely to succeed because the target areas for SHS installation will be in isolated areas or highlands where poverty is most pronounced. Donation (donated system) is possible, depending on donors' level of support and duration. Rental scheme may have reliable franchise network and a tendency of installing high quality equipment, but rental fee is high, not affordable for the poor. Hire-purchase scheme receives good financial support that makes systems price affordable for the poor in RE, but the scheme may face challenges of systems and service reliability, especially when demanding increased.

Technical Challenges

- Replace lead acid battery & light every 2-3 years,
- Too expensive for deep cycle lead acid battery,
- It is low quality of panels and short lifespan than the payment scheme,
- There is no supply chain,
- No recommendable component, which available in general market,
- Spare parts replacement is very costly,
- Poor system installation and maintenance by unskilled technicians.

Domestic Challenges

- There is no comprehensive SHS strategy.
- Projects are carried out independently without integrated national electrification plan.
- Target villages are selected extemporary based on local information.

- SHS promotion has not yet been clearly stated in the NSEDP or in Growth and Poverty Reduction Strategy or in 5-year Plan.
- Insufficient information and handbook supplied to users.
- Lack of public funding. Rural Electrification Fund (REF) now uses the fund for the purchase of the spare parts, mainly batteries.
- Lack of private incentive for investment.
- Sell livestock to cover the monthly fee in remote areas.
- Prefer grid electricity rather than off-grid one.

The Policy of SHS Program

- Solar Home Systems installation is one of the viable options for the off-grid component of rural electrification programs, and has been promoted by either national or international organizations.
- Consistent institutional and financial support, appropriate incentive measures, involvement of private sector, etc, are other important factors for success of the SHS programs.
- By observing the implemented pilot programs for SHS, government subsidy on hire- purchase scheme is considered the best practice or model for rural population in Laos.

Servicing and Customized Solutions

- The most interesting delivery models for SHS in Lao PDR include hire-purchase scheme, offered by rural electrification division (MEM) with Soft Loan support by the World Bank and Rental system – a pure commercial initiative offered by Sanlabob Rural Electrification Co.
- Currently lead acid in automotive batteries is used due to cheap and availability in general market. If replacing the lead acid one with deep cycle lead acid battery, the system would be working properly. However, this may be too expensive for those with limited financial resources.
- If the government can subsidize the cost of ordinary battery replacement and let users pay for the installation fee or fixing fee. The issue might be solved.
- If a proper supply chain is set up to control quality of spare parts, long SHS lifespan would last longer.
- Also, if technical staff is well trained to O&M the system closely, system failure rate might be reduced.

Local Supplies and Domestic Challenges

- If a data centre is set up to gather all relevant information related to SHS project implementations in Laos regarding number of systems actually installed and operating SHS plus any plan for expansion, this would help in assessing the project's output and impose necessary measures to manage the system in the long run.
- If the government is able to negotiate with the existing or new donors to obtain aid on SHS promotions in Laos, financial constrain might be no longer an issue.
- If an independent institution is set up to look after all government related projects directly in Laos, the issues on lack of co-operations between relevant institutions and management overlaps might be reduced.
- If campaign on SHS promotions is broadcasted nationwide, it may help to stimulate users' incentives and participations.

4. CONCLUSIONS

After identifying the situation, analysis, and studying a variety of SHS programs operating in Lao PDR, the following practices have been concluded:

- The well integrated government policy is crucial. The present policy on renewable energy only marginally touches on the SHS aspect, which is surprising considering that the market represents a success story out at the rural area.
- Long term system sustainability of SHS promotion program in Lao PDR depends on such factors system standards and quality, flexibility in spare parts supply, proper installation.
- Establishment of data centre is essential, in order to share experiences and lessons learned from failed and succeeded projects
- Workable institutional mechanism and good coordination among the relevant organizations are important factors for ensuring long-term sustainability in off-grid rural electrification programs and furthermore, to avoid overlapping either in term of promoted technology or funding support.
- Financial support to start-up capital or revolving fund for ESCOs can help attracting more involvement of private sector investment. In this meaning, soft loans to ESCOs by Rural Electrification Fund are essential.
- In other hand, the issues such as inconsistency in institutional support and policy inflexibility of delivery mechanism, improper system's standardization and management, inappropriate funding support probably are among the most important issues that need to be addressed in order to improve SHS promotion programs in off-grid areas.
- And, the members of the community can serve as salespeople and technicians if they receive proper training. The local supporters will understand the community and relate to the customers better than any outsiders.

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