Chapter 20
Selling Hours of Solar Lighting in the Evening

Leon Gaillard and Andreas Schroeter

20.1 Country Background

The Lao People's Democratic Republic (Lao PDR) features in the group of least developed countries (LDCs), with a UNDP Global Human Development Index (HDI) rank of 131 (out of 177 countries) (UN Lao PDR 2009). Significant improvements are primarily impeded by geographic and demographic conditions: 70% of the country is mountainous and thickly forested (Mongabay 2009), with highly dispersed and ethnically diverse population (82.9% of approximately 5.6 million) (Messerli et al. 2008) living in rural and remote areas lacking access to basic social infrastructure, communication, transport links, and professional opportunities, and where poverty tends to be more acute (Government of Lao PDR/UN Country Team 2006).

20.1.1 Access to Energy

In terms of energy, the utilization is still at low levels of technique and technologies, and the use of fuel wood still dominates and is supplemented by the use of fuel oil, charcoal, and electricity. It is worth noting that Laos imports all of its petroleum products (ADB 2006). Electricité du Laos (EdL) is the state-owned electricity provider and owner of the national grid. Hydropower plants provide 99.8% of grid electricity – due to many rivers and streams crisscrossing the country (EdL and Ministry of Energy and Mines 2008). At present, 58% of all households

L. Gaillard (✉)
Lao Institute for Renewable Energy (LIRE), Vientiane, Lao PDR
e-mail: leon@lao-ire.org

A. Schroeter
Sunlabob Renewable Energy Ltd, Vientiane, Lao PDR

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have access to electricity with only 50% connected to the national grid and 8% depending on isolated mini-hydropower plants and solar photovoltaic (PV) systems, as well as generators and car batteries (Messerli et al. 2008).

20.2 Project Overview

20.2.1 Sunlabob Renewable Energy Ltd.

The focus of this study is a project developed by a Lao commercial company, set up in 2000, licensed in 2001, and operating as a profitable, full-service renewable energy provider selling hardware and providing commercially viable energy services. It acquired unrivaled knowledge and experience of the local market and stakeholders, largely through solar home systems (SHS), comprising its first rural electrification efforts, which consisted in providing SHS to rural households, on a rental basis.

The success of a rural market PV rental business depends on a wide distribution network, which must be very cost effective and meet a very high standard of service. In order to achieve nationwide coverage, Sunlabob developed an extensive network of franchisees, who were all rigorously and thoroughly trained by the company to be responsible for the commercial development of the rental operation, the installation of PV systems, and the provision of maintenance services. Offering fast and reliable maintenance has always been core to the company's mission and interventions, as the systems' sustainability and longevity largely depend on this "after-sales" service. This independent distribution network, which plays an important role of developing new business, collections and maintaining a servicing network and commercial presence at the provincial level, only reinforced a belief that involving local individuals, loyal and empowered, is crucial for any rural electrification initiative.

The main lesson learned from the SHS was that, even on a rental basis, only the top third of village households on average could afford the systems. Second, systems must be adapted to the existing consumer behavior. For the SHS, money was collected by the franchisee from the end users on a monthly basis. This turned out to be difficult, as most rural households on the one hand do not have regular monthly incomes (largely depending on agricultural output) and on the other hand are not used to putting money aside on a monthly basis for their expenses. This gave rise to the idea of smaller but more regular expenses for lighting and paved the way for the development of the solar lantern rental system (SLRS).

According to the company director, a key lesson learned from the SHS project was that training village energy committees (VECs) is not a commercially viable activity, hence the need to involve other sources of funding for projects that have a large capacity-building component. Having said that, this is where the company acquired its expertise in providing training, both technical and administrative,

which is now used for the VECs and village technicians (VTs) who are involved in the SLRS.

Finally, the SHS program enabled the company to develop a strong relationship with the government of Laos and provincial and district representations. Due to difficulties mentioned above, the system is now gradually being phased out.

Based on its experience, the company believes that responsible, long-term-oriented entrepreneurship is the driving force for sustainable economic development and for providing the managerial, technical, and financial resources needed to meet social and environmental challenges.

Starting with a team of three people, operations in the Lao PDR grew from strength to strength into a company with a team of 42 full-time staff and offer a full range of renewable energy solutions, such as solar water pumps and heaters, water purification systems, street lighting solution, cooling units for health posts, and solar lanterns. The company is constantly developing new ways to promote renewable energy technologies in Laos and recently launched an Energy Efficiency department, responsible for conducting energy audits and advising customers on ways to save energy thereby reducing their environmental impact.

20.2.2 Institutional Arrangements, Project Partners, and Funding

Unlike foreign enterprises, companies licensed in Laos have permission to conduct rural electrification initiatives nationwide without the need for lengthy planning applications on a case-by-case basis. However, each individual initiative must be approved by the authorities of the province and district concerned. Generally in Laos, any electrification project below 100 kW is under the supervision of provincial authorities, and project over 100 kW requires central government authorization (EdL and Ministry of Energy and Mines 2008).

Arrangements with other partners are illustrated in Fig. 20.1.

The division of public and private ownership of assets is an important factor for the proliferation of the SLRS. The movable assets are a more feasible investment for the private investors. The private energy provider makes the "private investments" to own and operate the movable assets, namely the solar charging station, that is, the generating equipment. The public side, in this case the village, is responsible for the "public investments," namely providing lanterns to the village franchisee or users.

This innovative operational arrangement then leads to an innovative financial arrangement that allows for mutually leveraging opportunities. Consistent with a public-private partnership arrangement, the financing of the SLRS will be a combination of public funds to finance the public assets and private funds to finance the private assets. This arrangement allows public money to comfortably finance a project that 100% directly benefits the public and leverages the private sector. Private funds are able to leverage public funds to pursue a market that would otherwise be very difficult to operate successfully in. This concept can open markets and opportunities that would otherwise remain closed for a very long time.

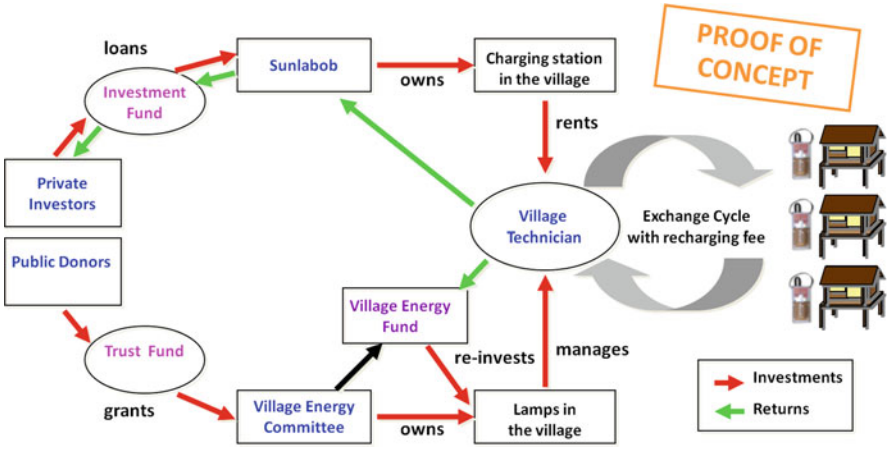

Fig. 20.1 Financial arrangements and partners for SLRS public-private partnership model (Source: Sunlabob Renewable Energy Ltd. 2008)

After the initial investment by the public, the launched village enterprises are expected to generate sufficient income to expand and continue their operations through the revolving fund without any further public investment, thereby ensuring sustainability of project.

20.3 Implementation Strategy

20.3.1 Delivery Method

To implement the SLRS, it is first necessary to identify a village entrepreneur who is interested in renting the SLRS and can be trained as a technician. The company will install the solar charging station at a central place in a village and will also be responsible for regular servicing of the station. The VT pays a fee to rent the solar charging station, but purchases the portable lantern units (with the help of public funds if necessary), which are then rented out to the village households interested in buying lighting. The village households pay a fee to the VT for renting a charged lantern or, viewed differently, for simply buying lighting.

The technician will operate on a franchise arrangement with the company. In return for a regular monthly fee on the charging station and for purchasing the lantern units, the franchisee is provided the following:

- Installation, regular servicing, and maintenance of the charging station
- Initial business and operational training, as well as ongoing advice and support
- Regular training for maintaining quality of equipment and data

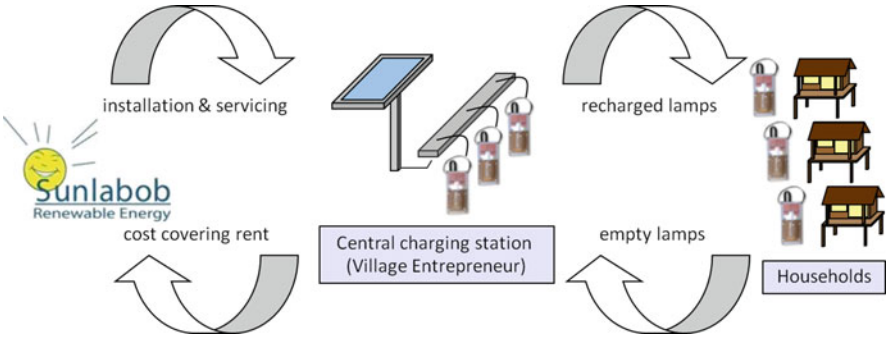

Fig. 20.2 Operational model for the solar lantern rental system (*SLRS*) (Source: Sunlabob Renewable Energy Ltd. 2008)

- Assistance in local marketing, through public relations (PR) materials, demonstrations, and campaigns
- Assistance in accessing soft loans if necessary

Figure 20.2 gives an illustrative representation of the operational flow of the SLRS model.

20.3.2 Project Activities

20.3.2.1 Present Status

The design and development process for the SLRS took over 1 year, including research and development on the components. Field trials played an important role, and at the time of writing, several pilot projects were being conducted in Laos, Uganda, and Afghanistan.

One of the objectives of the first pilot projects in Laos was to get a sense of how villagers would accept the solar lantern, focusing on ease of use, design, and types of usage. Another objective was to simulate the actual implementation of the SLRS to determine user behavior.

20.3.2.2 Product Package

The product and intervention package has been designed to replicate the behavioral patterns of rural households in terms of spending on kerosene. For the households, the recharging fee is a small regular expense, comparable to the established behavior of purchasing small amounts of kerosene regularly from the village outlet. The routine cycle of household expenditure therefore remains unchanged. Even the

act of going to the recharging station to "buy light" mimics the act of buying kerosene at the shop. As explained above, the operations result in the sale of hours of light, as opposed to the sale of equipment, which also emulates the service provided by grid connection.

The design of the SLRS is based on the idea of keeping construction as simple as possible, while still providing versatility, robustness, and ease of use. This is achieved by reducing the number of technical components to a bare minimum, placing most of the system's "intelligence" in the external system control unit (SCU). The system is entirely modular, and additional charging stations can be operated if required.

The Lantern Unit

The lantern unit comprises an energy efficient lamp, battery, and control electronics. These are designed to be portable and can be taken home, hung up, stood on a surface, or carried while illuminated. A robust tamperproof casing protects the internal components. Controlled use is ensured by an integral microprocessor, which records the total hours the lantern has been active since charging. The use of lanterns is carefully constrained while rented to a user. The lantern units are disabled after 10 h and cannot be turned on again by the customer. If used as a power supply, for example, to charge a cell phone and a low voltage condition is detected (flat battery), the integrated low voltage protection feature also results in the disconnection of the power outlet, and the lamp is switched off.

During the entire period between charges, the lantern unit's power output receptacle cannot be used to charge the unit's battery, ensuring that no unauthorized charging can occur. In order to prepare for charging, the lantern unit is connected to the SCU and can only be unlocked then. The SCU also reads the number of hours the lantern unit has been used since the last charging and writes it to the charging log, along with the lantern unit's unique identification and the current date and time. The lantern unit can then be connected to the battery charging unit until fully charged. While in charging mode, the internal controller prevents switching on the lamp and any attempt to extract power through the receptacle exceeding a set period. This approach ensures that only fully charged lantern units are handed out, but does not interfere with the operation of modern charge regulators that may probe the battery by discharging it for short periods of time.

Once the battery is fully charged, a lantern unit can be prepared for handing out to the next household, ordinarily in exchange for a spent one. It must be reconnected to the SCU to activate the lantern unit for lighting operation and record the lantern unit's ID to the activation log, along with the date and time. The integrated system is represented schematically in Fig. 20.3.

In addition to providing lighting, the lantern unit can be used as an unregulated 12-V power supply for small electronic devices. Possible uses include mobile phone charging or powering portable radios or mini-TVs. Any power extraction through the power outlet is measured, converted into an equivalent number of

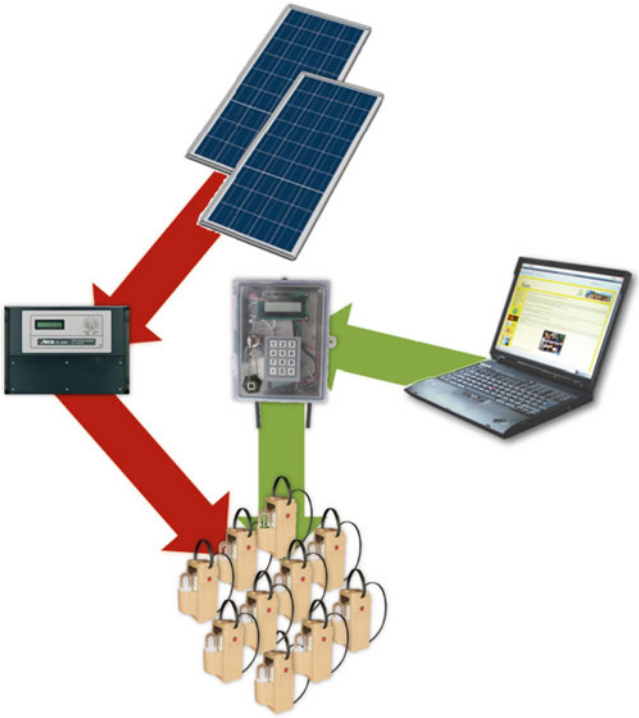

Fig. 20.3 SLRS control and supply schematic (Source: Sunlabob Renewable Energy Ltd. 2010)

lighting hours, and the operating time of the lantern unit is reduced accordingly. This ensures that the users get the exact amount of energy they pay for, whether they use the lantern unit for lighting, as a power supply, or both.

The System Control Unit (SCU)

The SCU is located at the charging station. It is used to activate the lantern units for either charging mode or for lighting mode by the households and to collect any data acquired since the last recharging. The SCU currently uses an integrated solid state (secure digital) storage module to store the log files and firmware updates of the associated lantern units. It is also used to store the SCU's firmware updates and configuration data. The size of this storage module can be increased to accommodate the needs of system setups with large numbers of lantern units per SCU.

Management Software

To facilitate the handling of data collected by many SCUs in many villages, the solar lantern recharging system comes with a management software complete with

a graphical user interface. The data collected can be analyzed in many ways, that is, number of charges and fluctuations in time, lamp distribution, intensity of usage in various areas, frequency of switching on and off, and average time of switched on light. The management software also enables firmware updates and is used to modify configuration settings of the SCUs.

20.3.2.3 Operational Details

The village entrepreneurs and the company enter a franchise agreement, which encompasses:

- The installation of the charging station, including the SCU
- The regular servicing of the charging station
- The sale of lantern units and of spare parts
- Regular training to maintain quality and introduce technical upgrades
- Operational and business advice
- Assistance in local marketing: PR materials, demonstrations, campaigns
- Assistance in accessing soft loans and financing opportunities

The rental income usually pays for these services, although various programs funded by public agencies may pick up some of the costs, for example, training.

20.3.2.4 Responsible Supply Chain

Laos is a largely agricultural country and has very few industries. This implies that the high-tech components of the SLRS have to be imported. Solar panels and batteries come from China, light bulbs from Singapore, and microprocessors and charging stations from Germany. However, in order to maximize the impacts of our activities on the country's development, the company purchases as much material as possible from local suppliers, which includes all the SLRS accessories (cables, outer box, straps, etc.) (COPE 2009).

20.4 Financing Mechanisms

In order to be adopted by the poorest rural households, the solar lantern must be competitive with the price of kerosene. Kerosene prices vary from country to country, but in Laos, households typically spend US$ 4–6 per month for lighting. In order to offer its system at low cost, the company has had to develop collaboration with public donors, thereby creating a public-private partnership for providing solar lighting to poor households in remote villages. There is a strong case to be made for public involvement in launching such ventures. However, public financial involvement must be designed to encourage private investments into commercial

operations. Subsidies, if badly designed, can be counterproductive. Public and private investments can offer mutual leverage, in circumstances where one alone may not achieve the intended effect. For the SLRS, private investors are to invest in the charging stations to be rented out, whereas publicly launched revolving funds provide the first batch of lanterns to start up the businesses of the village entrepreneurs.

Following the initial public investment, the system and models are designed in such a way that the village entrepreneur is expected to sustain his newly created business with the recharging fees alone and without any further investment.

Based on kerosene prices and rural households' incomes in Laos, the recharging fee for the solar lanterns has been set to 4,500 LAK (about US$ 0.53). The income from each recharging fee is to be split into four parts as follows:

- 1,900 LAK (42% of the recharging fee) is set aside in a maintenance fund managed in conjunction with the VEC, which is to be used for the purchase of replacement components.
- 1,100 LAK (25% of the recharging fee) is retained by the VT as a salary.
- 1,000 LAK (22% of the recharging fee) goes to the company as the rent for the charging station (paid by the VT).
- 500 LAK (11% of the recharging fee) is to be shared among the members of the VEC as remuneration for their time administering the system.

20.5 Capacity Development

The SLRS model makes full use of the existing institutional structures found in rural Laos. The development of a VEC, responsible for this service naturally fits in with the way in which villages traditionally manage their community-level affairs. Similarly, in terms of the VT, it is common to find one key competent individual in a community who is already identified by villagers as a focal point for technical issues or with an incline for commercial activities or providing access to material and hardware.

This project has the potential to create jobs for technically versatile people who are disadvantaged in rural areas because they cannot apply their skills there and often leave the village as a result and are lost from the local village economy.

Working on this existing structure, the company adds specific training and capacity building in order to enable these communities to manage SLRS.

Training for the VEC members includes:

- Energy service management
- Basic bookkeeping
- Maintaining transparency
- Community communications

Training for the VTs includes:

- System operation
- System maintenance
- Keeping records of the usage

For each village, the cost of capacity building is about US$ 500. This comprises the initial training sessions as detailed above and three coaching visits, over a period of 18 months. Capacity building costs in Laos are high because existing skills are relatively low, due to an underdeveloped education system. As an indication, the literacy rate in rural regions without road access is 41.1% for women and 67.6% for men, and nationwide, only 15.5% (14.6% female; 16.3% male) of the population aged 6 and above have completed primary education and 6.1% (5.4% female; 6.9% male) have completed lower secondary education (Messerli et al. 2008). In addition to a low level of skills, the technology brought to rural communities is very new, hence the need to spend a lot of time and money on capacity building. In the case of the SLRs, this is mitigated by the fact that the solar lanterns mimic existing behaviors with kerosene. However, in order to reduce training costs, the company trains VECs and VTs in groups of five to eight people from neighboring areas at the same time.

20.6 Impacts

In its current form, the impacts of the SLRS project show that it contributes largely to the efforts being made to achieve, in particular, three Millennium Development Goals (MDGs):

- MDG 1: Eradicate extreme poverty and hunger
- MDG 7: Ensure environmental sustainability
- MDG 8: Develop a global partnership for development

20.6.1 MDG 1: Eradicate Extreme Poverty and Hunger

The project improves the economic situation of poor households in several ways. First, most of the funds collected as charging fees remain in the village: the VT and VEC are remunerated in return for managing the service, and the rest of the money is retained in a maintenance fund, which is used for the benefit of the community and to buy replacement components or additional lanterns for the village households. Second, the SLRS is cheaper than kerosene per hour of light so end users spend less on lighting. The quality of light provided by the SLRS lanterns is also considerably better than that of traditional kerosene lanterns; one solar lantern can replace several kerosene lanterns, and the light of a single unit is sufficient to accomplish household chores or income-generating activities in the evening.

A study in Ban Phonlek shows that half the total number of households who are participating in the project are using the lantern for income-generating activities. Among them, half sell animals, a quarter sell handicraft products, and the other quarter sell general items. By increasing the number of productive hours, the system thus further improves the wealth of a household. Lastly, the SLRS dramatically increases energy security for poor households, since the price of kerosene fluctuates erratically, whereas the price of the SLRS is controlled. This makes household finances much easier to plan. Periodic price updates are planned based on the country's consumer price index (CPI). On a national level, locally produced renewable energy sources reduce the reliance on imported fossil fuels (100% for Laos) and further increase energy security by removing potential threats, such as political instability of energy-producing countries, manipulation of energy supplies, competition over energy sources, attacks on supply infrastructure, as well as accidents and natural disasters (ASPI 2007).

The SLRS project generates jobs both directly and indirectly. At the company's head office in Vientiane, the system creates the jobs involved in assembling the lanterns and providing the systems to rural areas. At village level, jobs are created for those providing the service to the end users, namely the VECs and the VTs. Finally, by increasing the number of productive hours in the day, the system indirectly, but purposely, creates income-generating opportunities.

The system itself introduces the need for local services with the creation of a small business run by the VT. The company's activities encourage a local technician to constitute his/her own microenterprise, technically and operationally safeguarded through a franchise arrangement with the company providing experience and competence. VTs are trained to correctly service and maintain both the charging station as well as the rechargeable lanterns in order to ensure longevity. The concept combined with the skill improvement allows them to run their own sustainable business, supplementing other income sources. With a single charging station (50 lamps), the VT receives a net income of around US$ 400 in the first year of operation. Compared to a gross national income (GNI) per capita of around US$ 600, which includes the higher-income urbanized communities, the SLRS microenterprise provides the VT with a decent income.

The SLRS also introduces the concept of fee-for-service in rural communities, which could result in other local enterprises using it as a model for their business. In addition, through contact with the company, rural households gain awareness of other renewable energy technologies and services that they may wish to develop in the village and run as a microenterprise, for example, TV/Video or even projector with screen, coolers, a laptop with GPRS Internet connection, or UV-sterilized bottled drinking water.

In terms of access to telecommunication systems and information, in Laos, the information and communication technology (ICT) sector is still emerging (UNCTAD 2007), but many people demand more information to expand their knowledge and reduce poverty (Vientiane Times 2009). Access to information and knowledge has been identified by the Government of Laos, during the eighth Party Congress in 2006, as a crucial prerequisite to alleviate poverty in rural areas

and boost the country's socioeconomic development (Vientiane Times 2009). The Government is currently working to develop useful information in print, radio, and TV formats for rural households on topics that concern them, such as agriculture, public health, income generation, and poverty reduction (Vientiane Times 2009). In addition, the government sees the media as "an important nation building asset [. . . and . . .] a tool to disseminate the Party's policies, laws and regulations" (Vientiane Times 2009).

20.6.2 MDG 7: Ensure Environmental Sustainability

The main aim of the project is to reduce fossil fuel consumption for lighting. It is estimated that fuel-based lighting such as kerosene lamps consumes 77 billion liters of fuel annually throughout the world, equivalent to 1.3 million barrels of oil per day (LBL 2005). The average daily burn time of one kerosene lamp per household is 3–4 h, which sums up to around 40 L of kerosene consumed per year.

Furthermore, the light provided by a kerosene lamp is inefficient in terms of useful lighting. Theoretically, more than one kerosene lamp per household has to be used for sufficient lighting which further increases the kerosene consumption. The kerosene used for domestic lighting can also find its way into vehicles with additional environmental consequences (Mills 2000). In addition, the SLRS also reduces the amount of fossil fuels used for the transport of the lighting fuel.

Energy use and production affects local, regional, and global environments. According to Lawrence Berkeley National Laboratory (2005), the single greatest way to reduce greenhouse gases associated with lighting energy use in developing countries is to replace kerosene lamps. Nearly 100 kg of carbon dioxide (CO_2) are emitted per year by each kerosene lamp (Mills 2003). As part of the SLRS, the actual usage of each lantern is recorded in detail by the internal microprocessor, and data is collected and aggregated at charging stations. By basing its calculation directly on the offset of kerosene, the company will be able to precisely quantify the emission reduction achieved. Sunlabob is currently working on strategies to enter the carbon trading market using the clean development mechanism (CDM).

In terms of affordability, the SLRS is directly competitive with kerosene. It is sustainable due to the equipment lifecycle being carefully included in the operational model so that high-quality service can be provided to the lantern users on a long-term basis. Finally, in terms of environment, by using solar energy to power the charging stations, the SLRS has a low impact.

By eliminating the use of kerosene lanterns, the solar lanterns solve two serious problems associated with the usage of kerosene lamp. First, many homes have poor ventilation so that burning kerosene lamps causes indoor air pollution resulting in health hazards such as lung and eye infections and respiratory problems. The light is so poor that the users can only work or read if they are almost directly over or nearby the flame inhaling even more of the toxic fumes. Second, kerosene lamps as flammable liquids have more probability of causing burns and fires than all forms of

electric lighting, primarily due to overturned or toppled lamps. Each year, many homes and even entire communities worldwide burn to the ground (Pode 2008). The solar lantern in fact neither has an emission of any kind nor poses any technical risks to the user. SLRS offers rather an affordable, clean, healthy, safe, and sustainable energy source.

The SLRS increases energy efficiency by providing high-quality light compared to kerosene lamps. The light output of a kerosene lamp, measured in lumens, is 45 lm compared to the SLRS's 4-W compact fluorescent light bulb with 120 lm. The lanterns also promote efficient use of energy as a flashing LED which clearly indicates the number of remaining hours of light (out of the initial 10 h), enabling villagers to manage and plan their energy usage efficiently.

20.6.3 MDG 8: Develop a Global Partnership for Development

The SLRS projects bring to Lao villagers a sense of being part of the global scene by exposing them to international products with state-of-the-art technologies, new organizational approaches, and global actors. A learning process with VECs and VTs is initiated with long-term potential. The establishment of VECs also has numerous positive impacts on communities in terms of management issues, responsibility, or social cohesion.

The concept has been extended beyond the boundaries of Laos, by engaging into South-South cooperation initiatives, as illustrated by the current projects in Uganda and Afghanistan. Three representatives of African enterprises came to Laos to learn about the company's range of products and practices. The delegation visited several implementation villages, where technicians explained their role, and the benefits they saw to their own households and their community. The event was a rare encounter of people from African nations and rural Laos and represented the coming together of two different peoples that face some common challenges for development. Indeed, it is the similar needs in some developing nations, and moreover the firsthand understanding of those needs that can be an advantage for South-South exchanges over the historical North-South dissemination of technology.

20.7 Project Sustainability

20.7.1 Ensuring High (Robust) Quality of Product

An analysis of the market revealed a market gap. Indeed solar lanterns have been widely propagated as a solution for lighting in remote villages away from the grid. Standard solar lanterns, however, have shown to fail much earlier than expected. One reason is that low-quality components are often used to reduce costs of manufacturing to make the lanterns more affordable. Another is that batteries are

often irregularly charged, or households engage in "hotwiring" to use the batteries for operating other equipment, resulting in early battery failure. The result is that solar lanterns have not made a broad breakthrough in poor rural areas and that kerosene still rules the off-grid lighting market.

The challenge for the company was therefore to find an operational scheme for solar lanterns that could:

- Use advanced charging equipment and tamperproof units to exploit the full life expectancy of components
- Tightly control the use and charge status of the lanterns, and monitor the life cycle of their components, thereby increasing their real on-site efficiency
- Reduce costs per hour of light to be commercially competitive with kerosene lanterns on a household level.

With such innovations, it is hoped that solar lighting can make a significant impact in thousands of low-income rural households in the developing world.

20.7.2 Matching the Product with Consumer Behavior

The SLRS product was specifically developed in response to a direct consumer demand. During the course of its previous solar panel rental scheme, villagers in the areas reached by installation teams frequently asked for a cheaper alternative to the SHS. The SLRS fills a gap in the market, namely the need for reliable lighting and low-power charging (e.g., for mobile phones), for low-income households.

Another advance in the service arrangement from SHS to SLRS was to move away from a monthly rental fee to instead a fee based on the level of use. Moreover, by introducing monitoring features to indicate the state of charge in a lantern, users are directly in control of their energy consumption.

Certain features of the lanterns have also been strongly affected by consumer choice. Examples of this include the use of compact fluorescent light bulbs instead of LEDs and the placement of straps to enable the units to be both carried and hung.

As described in preceding sections, SLRS mimics conventional behaviors associated to the use of kerosene for lighting purposes. This is a significant design choice in the system to improve its sustainability, as it has a minimal impact upon existing supply chains within the village.

Finally, since the SLRS is operated and maintained locally by the VT and VECs, consumers are in direct contact with their service providers. Consumer satisfaction is highly visible and has an immediate effect upon those responsible for the systems.

20.7.3 Local Ownership

Local ownership is another essential element of the project's sustainability. At the end-user level, it is crucial that the community wishes to adopt the system and have ideas about how they might effectively use the new technology. It is also important

that they pay a small fee to charge the lanterns because the company's experience has shown that when such technology is provided for free, there are few incentives for end users to look after the equipment. In this configuration, the fees also allow to remunerate villagers to look after the system on behalf of the community. The VT is chosen to maintain the system and replace components when they have reached their end of life, using the money set aside for that purpose. This ensures that the system continues to function independently of external technicians going to the village to carry out repairs. Finally, the VEC guarantees that the money is collected and allocated properly so that a high-quality service can continue to be delivered to end users. It is therefore in the interest of all community members to look after the system and ensure its longevity.

20.7.4 A Profitable Business for Everyone

As detailed above, the SLRS concept was designed in such a way that all stakeholders involved benefit from the system. End users get safer and brighter lighting at a price equivalent to their traditional kerosene expenses. VTs run the SLRS charging as a small business, and as such have interest in selling as many "recharging fees" as possible, and hence ensure that the charging process and lanterns function properly. In addition, they gain an employment opportunity, additional skills, and access to potential new business ideas. VECs safeguard the sustainability of the project and thereby reassert their role as a governing entity and actively contribute to the development of their communities.

Beyond the initial investment, the village is empowered to operate the SLRS with minimal technical support from the company. Over three quarters of the money generated by the system stays within the community and the largest fraction of this is used by the village to maintain the system. It is also important to ensure that the fee structure is transparent and well understood in the villages. The income generated for the community supports the sustainability of the SLRS through its effect upon the level of buy-in by the villagers, since it generates a good perception that continued use of the SLRS is serving to bring wider development of the community.

20.8 Conclusions

Experience gained before and during the development and implementation of the SLRS has shown that technical expertise is essential but needs to be combined with a robust operational and financial model offering economic sustainability, in order for rural electrification programs to have long-lasting benefits for populations in developing countries.

By taking a fee-for-service approach, high quality can be ensured in terms of both hardware and operation with the lifetime and status of components being continuously monitored through the rental and return cycle.

The systems benefit from the support structure of a competent private enterprise external to the village while still being run very much as local businesses. Strong commitment and buy-in of local populations is therefore decisive in the success of the systems.

Finally, by purchasing hours of light instead of hardware, end users gain considerably more control over their energy expenses and greater flexibility in managing their energy consumption. Moreover, by empowering rural communities to be responsible for their power supply, the SLRS contributes to wider community development.

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