ENHANCING CAPACITY FOR SOLAR PHOTOVOLTAICS IN RURAL NEPAL

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ABSTRACT

Women in the remote district of Humla in Nepal are largely responsible for organising and utilising traditional household energy sources and can benefit from access to improved energy services such as a solar photovoltaic (PV) system for basic indoor lighting. Solar PV lighting systems can reduce the time burden for collecting fuel, reduce indoor air pollution and reduce the risk of burns. However, local capacity for maintaining and repairing PV systems is essential for their continued operation in remote areas. This paper discusses the capacity development activities of a non-government organisation, Rural Integrated Development Services Nepal (RIDS-Nepal), within its holistic community development approach. Special attention is given to the influence of gender on capacity development.

Keywords: photovoltaics; capacity development; Nepal

1 INTRODUCTION

Modern energy services, such as basic indoor lighting and telecommunications, are important for the development of a community. However, low population density, low electricity demand and challenging terrain make extension of the electricity grid in rural areas expensive. Solar photovoltaic (PV) systems can be a cost effective way of providing access to electricity in these circumstances as PV systems can be installed close to where the energy will be used, expanded as energy demand increases and eliminate ongoing fuel costs. In addition, PV technology makes use of renewable resources and does not contribute to global warming (once the system has generated enough energy to cover its imbedded energy). Thus, PV technology has increasingly been used in rural electrification projects around the world.

Past PV rural electrification projects have struggled to build the capacity of individuals, organisations, networks and institutional environments to ensure that PV systems continue to provide their expected energy services throughout their intended life cycle. In particular, the involvement of women in PV projects in the past has been limited or non-existent, even though women are most often the main managers of energy in the household.

RIDS-Nepal takes a long-term, holistic approach to community development which delivers lighting, clean water, sanitation and improved cookstoves in an integrated manner. This paper will assess the effectiveness of their approach in developing capacity for PV lighting systems. Section 2 will briefly review the situation in Nepal and Humla. Section 3 will define ‘capacity development’. RIDS-Nepal’s holistic community development approach will be described in Section 4 and their solar PV lighting project will be described in Section 5. RIDS-Nepal’s capacity development activities will be presented in Section 6. Section 7 will analyse the holistic community development approach with respect to capacity development. Finally, Section 8 will discuss the significance of the findings for solar PV projects elsewhere and offer some recommendations for their implementation.

2 BACKGROUND

Nepal is a mountainous, land locked country and is one of the least developed countries in the world (it is ranked 157th out of 187 countries in terms of human development [1]). Only 52% of adults are literate and the average life expectancy at birth is 64 years [2]. About 80% of the population live in rural areas. The country relies on traditional fuels to fulfil its energy demand (86.5% of total energy share came from traditional sources in 2010) and only 56% of the population has access to electricity. Nepal has not been able to fully exploit its huge potential for hydropower due to a lack of financial and technical capability. Renewable energy only accounts for 0.7% of total energy share [3].

Solar PV has been used for rural electrification in Nepal since 1988, but has only gained momentum after subsidies from the government's Energy Sector Assistance Program and the Alternative Energy Promotion Centre were introduced in 1996. The solar PV applications in Nepal include solar home systems, solar lanterns, community solar PV systems and PV installations in public institutions. Solar home systems are the most widely used type of PV solar system and 225,000 such systems have been installed to date with an approximate output of 5.36MWp. The first sector specific policy statement for using renewable energy in rural areas in Nepal was the Rural Energy Policy 2006. This policy positions solar home systems as the main rural electrification strategy in areas where grid connection and micro-hydropower are not feasible. The Subsidy Policy for Renewable Energy 2009 sought to make existing subsidies more equitable, inclusive and effective [4].

Humla is a district in the north-western corner of Nepal and is extremely isolated (it is not well connected to the national electricity and road networks). It is in one of the least developed areas of the country (the Human Development Index for the mid-Western mountain region to which Humla belongs is 0.435, which is about 85% of the national average of 0.509 [2]). Humli women experience the greatest levels of gender inequality in Nepal (with a Gender-related Development Index of 0.414 in the region, compared with 0.499 in the country [2]).

Villagers in Humla have traditionally burned resin soaked Himalayan pine sticks called *jharro* for indoor lighting. This generated dim lighting, contributed to high levels of indoor air pollution and posed a fire risk for its users. The females in a household are typically responsible for collecting the resin.

3 DEFINING 'CAPACITY DEVELOPMENT'

The concept of capacity development emerged in the late 1980's in the field of international development. It addressed issues arising from previous experience with delivering aid which lacked long-term impact, local ownership and appropriate technologies. It evolved from other development ideas, including institution building, institutional development, human resource development, development management and institutional strengthening [5]. Capacity development remains central to discussions about the effectiveness of international development today. However, the concept of capacity development is ambiguous and different international organisations have taken different approaches. Lusthaus et al. [5] offers a useful classification of these approaches:

- Organisational approaches, which focus on building the capacity of specific organisations,
- Institutional approaches, which focus on creating, changing and reinforcing rules and processes that govern society,
- Systems approaches, which see capacity as a multi-level entity, and
- Process approaches, which work in participatory ways to engender local ownership of the outcomes.

This paper will adopt a systems approach to examining the contribution of RIDS-Nepal's holistic community development approach to capacity development for solar PV lighting systems. In this paper, capacity is defined as "the ability of a human system to perform, sustain itself and self-renew" [6]. Here, human system refers simultaneously to various levels or scales of human organisation which interact with each other. Thus, individuals, organisations, sectors, networks of actors and nations can have capacities [7]. Capacity development is both an endogenous and continuous process of change, as well as deliberate efforts to help capacities grow.

In the context of solar PV projects, capacity means the ability to use energy services to accomplish development outcomes. A high level of capacity would include technical aspects (such as the ability to maintain and repair solar PV systems quickly), as well as social and organisational aspects (such as the ability to identify local renewable energy sources and the ability to make informed decisions about how renewable energy could be used).

Common capacity development measures for solar PV in developing countries are limited to short-term provision of technical expertise, training and awareness raising for government ministries, energy utilities, financial institutions, non-government organisations, actors in the service delivery chain and end-users [8]. These activities target the technical capacities of individuals, but do not directly address the need for capacity development at other levels.

4 A HOLISTIC COMMUNITY DEVELOPMENT APPROACH

RIDS-Nepal developed and implements projects based on two long term, holistic community development concepts called the "Family of 4" and the "Family of 4 Plus". The "Family of 4"[1] includes the following four services for each household in a village (see Figure 1):

1. A pit latrine,
2. A smokeless metal stove,
3. Basic indoor lighting via renewable energy,
4. Clean communal drinking water supply.

FIGURE 1: THE "FAMILY OF 4"

RIDS-Nepal have found that these are the most common self-identified needs of communities in Humla. Other services, as part of the "Family of 4 PLUS" are added to the long term program, once the "Family of 4" is fully implemented. The local community identifies additional needs they wish RIDS-Nepal to help them address. These additional components include non-formal education for women and girls, high altitude greenhouses, solar driers, a nutrition program for children less than 5 years old and their mothers, slow sand water filters for indoor use, solar cookers, a high altitude bathing centre for improved personal hygiene and a scholarship program for local young people to undertake a 2 ½ year apprenticeship program. All of the elements of the Family of 4 and Family of 4 PLUS are integrated with each other and supported on a long-term basis (up to 20 years) to form the holistic community development approach.

5 SOLAR PV LIGHTING SYSTEMS

The solar PV lighting systems, designed and installed by RIDS-Nepal, provide better quality indoor lighting, without the health impacts of using traditional *jharro*. The solar PV lighting systems are designed to take account of the amount of sunlight available locally, as well as to the physical layout of each village (see Table 1 and Figures 2 to 4 for a description of the three types of solar PV system configurations installed by RIDS-Nepal). The solar PV systems are heavily subsidised by RIDS-Nepal, with the local people paying approximately 10% of the total system costs (including air transport). Between 2005 and 2011, RIDS-Nepal installed a total of 388 solar PV systems[2] for basic indoor lighting in 11 villages, serving about 3,500 people.

TABLE 1: TYPES OF P.V. SYSTEMS

Config.	**Situation**	**Sample System Description**
Central Solar PV Village Tracking System	All the homes in the village are located close together and the villagers are mostly from the same caste	*Tulin Village (29 households)* • 3 x 1W white light-emitting diode (WLED) lights per house, • 4 x 75W PV modules mounted on a 2-axis tracking frame • 400 Ah capacity, deep-cycle battery bank (designed to give 7 hours of lighting) • 24V DC system voltage • Charge/discharge controller • Armoured underground cabling between homes
Solar PV Cluster Village System	The village is divided into small clusters of homes (usually according to caste). Clusters are located some distance from other.	*Pamlatum village (4 clusters of 4-8 homes each)* Each cluster has: • 3 x 1W WLED lights per house • 75W PV module mounted on a 1-axis adjustable frame (0-60° South) • 200Ah capacity, deep-cycle battery bank

		(designed to provide 7-8 hours of lighting) • 12V DC system voltage • Charge/discharge controller • Armoured underground cabling between homes
Solar Home System	Homes in the village are randomly scattered	*Dharapori village* Each home has: • 3 x 1W WLED lights per house • 16W PV module mounted on a 1-axis adjustable frame • 14.4Ah sealed battery bank (designed to provide 7 hours of lighting) • 12V DC system voltage • Charge/discharge controller

FIGURE 2: CENTRAL SOLAR PV VILLAGE TRACKING SYSTEM AT TULIN VILLAGE

FIGURE 3: SOLAR PV CLUSTER VILLAGE SYSTEM AT PAMLATUM VILLAGE

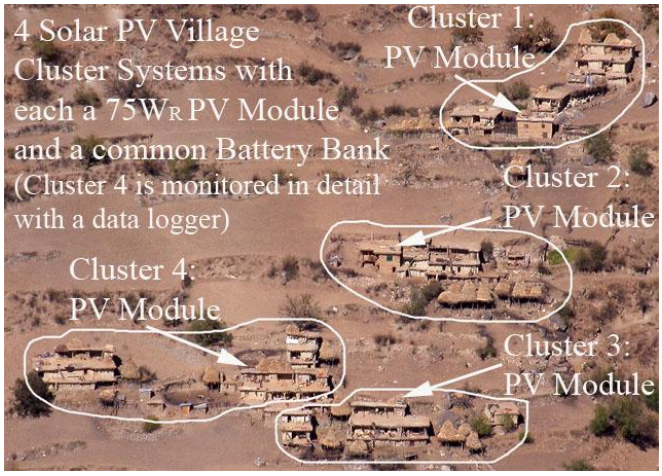

FIGURE 4: SOLAR HOME SYSTEM AT DHARAPORI VILLAGE

6 CAPACITY DEVELOPMENT FOR SOLAR PV

6.1 Capacity Development Activities

Capacity development for the PV lighting systems is integrated into all elements of RIDS-Nepal's "Family of 4" and "Family of 4 PLUS" programs. Activities aimed at increasing the capacity for solar PV in Humla include:

- Awareness raising: Awareness of the potential benefits of solar PV lighting systems is created through songs, brochures, posters, word-of-mouth, and community visits by RIDS-Nepal staff.
- Community involvement: Before the start of a project, RIDS-Nepal helps to set up a local project

steering committee. The steering committee works with RIDS-Nepal to motivate and liaise with each family participating in the project. Each household in the village must apply to be a part of the project. These processes encourage a sense of community and personal ownership of the lighting system.

- Sense of ownership: In addition to the processes for community involvement discussed above, RIDS-Nepal uses a staged approach to working with communities. The community must first build a pit latrine under the direction of RIDS-Nepal, purchase and install a smokeless metal stove in each home, before the solar PV project commences. Each household must also pay for part of the cost of the solar PV lighting system and agree to pay a small fee to cover maintenance costs. This means that by the time the solar PV lighting system is installed, the household has already contributed resources and time to the project, which helps to engender a sense of ownership and value.
- Technical training: Each village self-selects 1-2 people to attend a technical PV training course run by RIDS-Nepal where they learn maintenance and repair procedures. As part of the training, participants assist RIDS-Nepal staff with installing PV systems in their own village.
- Information for women: Basic operation and maintenance instructions are included in RIDS-Nepal's numeracy and literacy program for women and children who cannot attend school (the Non-Formal Education program). As the classes are run at night, PV systems are used to provide lighting, which creates greater awareness of solar PV technology.
- Local employment: RIDS-Nepal has a policy of employing only Humla locals as staff for their field projects. The staff members receive extensive on-the-job training, including installing and repairing solar PV lighting systems.

6.2 Results

As a result of these activities, awareness of solar PV systems has increased and a basic understanding of how to operate and maintain the systems has become more widespread. However, capacity for solar PV systems in villages that RIDS-Nepal works with remains low.

RIDS-Nepal has found that villagers in Humla are not able to set aside funds for maintenance and repair of solar PV systems, and will use the traditional *jharro* method of lighting if the solar PV system fails (as it does not require cash to collect the resin and wood). The people who have attended the solar PV training course (mostly young men) often leave Humla on a seasonal basis for trading or for work in larger cities. In addition, spare parts are too expensive to purchase or unavailable locally. The three different types of systems used by RIDS-Nepal means that it is difficult for villagers to build up expertise in any one type of system.

At present, the villages that RIDS-Nepal works with cannot be said to have a high level of capacity for solar PV lighting systems as they cannot maintain and repair them without support from RIDS-Nepal. RIDS-Nepal has found the need to institute a long-term follow-up program, which often involves providing free repair and maintenance, while encouraging villagers to set aside funds to cover these costs in the future. RIDS-Nepal plans to continue the follow-up program for an extended period of time as economic circumstances are unlikely to change quickly. However, it is becoming increasingly unsustainable for existing staff to travel to each home to perform maintenance and repairs as RIDS-Nepal expands its operations to more villages. As a result, villagers sometimes need to wait up to several weeks for repairs to be completed.

7 ANALYSIS OF CAPACITY DEVELOPMENT

RIDS-Nepal's holistic community development approach tightly integrates solar PV lighting into a multi-pronged development program which is tailored to local needs. This means that capacity development activities for solar PV technology are built into all aspects of the "Family of 4" program. However, RIDS-Nepal's holistic community development approach has had limited success with capacity development for solar PV because:

1. it has little influence over the institutional environment and wider development trends as a local NGO project, and
2. it has relied on financial resources and technical expertise from outside Humla.

RIDS-Nepal's experiences demonstrate that targeted solar PV capacity development activities will have limited impact if capacity in other areas is not well developed. These capacities include sufficient financial resources to pay for maintenance and repair, and local technical expertise.

At the national level, the Nepalese government has defined a role for solar PV in the development of the country, along with consistent policy instruments to expand the use of the technology for rural electrification. Supply chains for solar PV systems have been gradually built up across the country. As the capacity for solar PV at the national level is strengthened and the level of development in the country continues to improve, the efforts of RIDS-Nepal to improve capacity for solar PV in Humla will begin to bear fruit.

However, these changes will be gradual and RIDS-Nepal plans a long-term engagement with the communities in Humla. This approach is time and resource intensive, making it difficult to scale-up without long-term financial commitments from external sources.

There are two complementary avenues that RIDS-Nepal could take to improve the capacity for solar PV in Humla. The first is to gradually phase out free maintenance and repair services provided by RIDS-Nepal and to support the creation of jobs in solar PV system repair in local area. This would involve emphasis on income generation aspects of the "Family of 4" and "Family of 4 PLUS" programs so that households are able to set aside funds for maintenance and repair of their solar PV systems. More advanced technical training could then be given to suitably qualified villagers (such as the local electrician) to repair solar PV systems. Capacity could also be improved with the use of standard parts so that technicians can focus on repairing a limited set of components and stock appropriate spare parts.

The second avenue to further develop capacity for solar PV in Humla would be to improve women's involvement. Women are the main managers of traditional energy in the household and tend not to travel outside of the local area for work. Despite RIDS-Nepal's present effort, women in Humla currently have limited involvement with maintaining their solar PV systems. This can be attributed to traditional gender roles in relation to different technologies, and to the limited opportunities for women to participate in solar PV training. Villages always select males to attend the solar PV system maintenance and repair training course because electricity is seen as part of the male domain and few females meet the educational requirements needed to participate in the course. Female participation could be improved as improvements are made to gender inequalities in education so that more females meet the minimum requirements for undertaking the training course. RIDS-Nepal could also expand the content on solar PV systems, which are included in its non-formal education program for females.

In the experience of RIDS-Nepal, changes in gender roles and greater gender equality have occurred organically as education levels of females improve. The improved status of women may lead to women's time being valued more highly and encourage investment in maintaining solar PV systems (as this reduces the time they have to spend collecting resin). Women in Humla spend more time inside the home than men, so they may value solar PV lighting more because they suffer more from respiratory conditions after prolonged use of *jharro*. As women's influence on decision-making improves, then investment in maintaining solar PV systems may also improve.

8 CONCLUSIONS

This paper used a systemic approach to capacity development for solar PV, which offers a broader view of capacity that includes national goals, policy instruments, education, gender equality and technical capacity. In this context, capacity for solar PV lighting can be developed in a systematic way through a long-term, holistic community development approach. RIDS-Nepal's approach not only integrates specific solar PV capacity development activities into its programs, it also addresses other domains, such as economic development and gender equality, which can impact on capacity for solar PV lighting. However, capacity at the national level is also required in the form of an enabling institutional environment. In circumstances where capacity is initially low, such as in Humla, solar PV projects should plan to engage with the community for a long timeframe, act in concert with other development activities and consider how new technologies will interact with existing capacity.

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10 REFERENCES

[1] UNDP, *Human Development Report 2011 - Sustainability and Equity: A Better Future for All*. New York, USA: United Nations Development Programme, Palgrave Macmillan, 2011.

[2] UNDP, "Nepal Human Development Report 2009: State Transformation and Human Development," United Nations Development Programme, Kathmandu, Nepal, 2009.

[3] S. K.C., S. K. Khanal, P. Shrestha, and B. Lamsal, "Current status of renewable energy in Nepal: Opportunities and challenges," *Renewable and Sustainable Energy Reviews*, vol. 15, no. 8, pp. 4107–4117, Oct. 2011.

[4] A. Gurung, A. Kumar Ghimeray, and S. H. A. Hassan, "The prospects of renewable energy technologies for rural electrification: A review from Nepal," *Energy Policy*, vol. 40, no. 0, pp. 374–380, Jan. 2012.

[5] C. Lusthaus, M.-H. Adrien, and M. Perstinger, "Capacity Development: Definitions, Issues and Implications for Planning, Monitoring and Evaluation," Universalia, 1999.

[6] J. Ubels, N.-A. Acquaye-Baddoo, and A. Fowler, *Capacity Development in Practice*. UK: Earthscan, 2010.

[7] J. Bolger, "Capacity Development: Why, What and

How," Canadian International Development Agency, 2000.
[8] IEA-PVPS, "PV for Rural Electrification in Developing Countries: A Guide to Capacity Building," International Energy Agency, 2003.

[1] The name "Family of 4" refers to a nation-wide campaign run by the Nepalese government to identify a "family" as consisting of a father, a mother, a son and a daughter, in order to elevate the value of newly born girls into a family as equally valuable as boys. Thus, RIDS-Nepal's holistic community development concept of the "Family of 4" is based on a concept with is familiar to the communities in Humla.

[2] The total of 388 solar PV systems includes 346 solar home systems, 29 solar PV cluster systems, and 13 solar PV central tracking systems for whole villages, health posts, local schools or NGO offices.