---- Handling Available Resources Responsibly ----
Case Study of a Renewable Energy Project with a Remote and Poor Mountain Village in the Nepal Himalayas

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Abstract

Almost all of the 2 billion people with no access to electricity live in developing countries, and four out of five live in rural areas. Nepal is a clear example of that relationship. Families in the remote areas use precious trees for cooking, room heating and light. These activities, especially the indoor cooking on open fireplaces, have a direct chronic impact on the health and extremely low life expectancy of the women and children along with devastating deforestation. In a remote and poverty stricken mountain village in the northwestern district of Humla Nepal, Kathmandu University and the ISIS Foundation are trying new ways to utilize the locally available renewable energy resources in a more affordable, sustainable and appropriate way. The rich solar energy resource is tapped to generate electricity for an elementary lighting system. A self-tracking solar PV system in the center of the village powers three 1-Watt WLED (white light emitting diode) lights per household through underground wiring. Additionally, in each household an efficient, smokeless, metal stove for cooking and heating is installed. It consumes only half the usual amount of firewood, enabling a smoke free, and save environment in the home. A pit latrine per house, and a common village drinking water system are also an intrinsically part of the holistic community development project. Project planning, installation, training for operation and maintenance, are all implemented in close partnership with the community and are part of the excitement. Renewable energy resources are a foundation for holistic community development of our poor and marginalized 2 billion neighbors. This paper describes the process, implementation and partial evaluation of the project.

1. Introduction

More than 99% of the identified 1.64–2 billion[1] people without access to electricity live in developing countries, and four out of five live in rural areas[2]. Today, 100 years after Edison's seemingly forward-looking statement which said "we will make electricity so cheap that only the rich will burn candles" [3] was only true for the industrialized countries. Who anticipated that today more people have no light in their homes in the developing world than the world's population in Edison's time?

There is a clear relationship between poverty and access to electricity[4], and poverty levels increase the more remote and difficult to access the communities live, while costs for an electrification project increase due to transport and support costs. 80% of Nepal's 25 million people live in the rural areas, and about half of these, or approx. 10 million people, live in such remote and difficult to access areas that neither a road nor the national electricity grid will reach them, for decades to come.

Families in the remote areas use precious trees for firewood for cooking, room heating and light. These activities, especially the indoor cooking on open fire places, have a direct chronic impact on the health and the extremely low life expectancy for women and the high death rate of under 5 years of age children[5]. Deforestation has reached alarming conditions. The once picturesque, bio-diversity rich forests and valleys are stripped of their resources in unsustainable ways. The drinking water is taken from dirty streams, as there are no latrines or clean and pure water springs tapped into. Nepal has no fossil fuel resources, but plenty of renewable energy resources such as water, sun and wind.

In Chauganphaya, a remote and poverty stricken mountain village in the north-western district of Humla Nepal, new ways to utilize the local available renewable energy resources in more affordable, sustainable and appropriate ways, have been tried out. In each household, three 1-Watt lights, powered

[1] E. Mills, *The $230-billion Global Lighting Energy Bill"*, Lawrence Berkeley National Laboratory, 2002
[2] IEA, *World Energy Outlook 2002*, chap. 13, page 373
[3] E. Mills and S. Johnson, *"A Dramatic Opportunity for Technology Leapfrogging in the developing World"*, Lawrence Berkeley National Laboratory, 2002
[4] IEA, *World Energy Outlook 2002*, chap. 13, page 375
[5] More details in *Smoke-the Killer in the Kitchen*, Hugh Warwick et al, ITDG Publishing 2004, ISBN 1 85339 5889

by a commonly owned, centrally located solar PV system, with underground wiring, are installed. Further, an efficient smokeless metal stove, designed and developed. This stove is for cooking and heating. It consumes only half the firewood of a usual open fire. It enables a smoke free, safe environment in the home for women in children. Additional, to address the community's needs in a holistic way, a pit latrine, and a common village drinking water system, are implemented in close partnership with the community. Project planning, installation, local training for operation and maintenance, are all part of the excitement.

2. The Human Face in a Project

It is crucial to understand that the local community is at the center of any holistic development project and that the technologies applied are to serve and support their struggle for a better life. That means, that any project has to start out by first understanding their context, their language and culture, and to come to an understanding of the "unspoken" and "invisible" causes of poverty, decades of deprivation of chances and opportunities. In this way it is possible to extract and grasp what the real needs and issues are, seen and felt from their perspective and world view. That demands time, compassion and dedication - parameters which are difficult to assess and judge, and for sure, not easy to "sell" to a donor, but are crucial for a project which aims to empower and lift up a community deeply steeped in poverty and hopelessness. These more "human" aspects of a project are crucial factors which need to go alongside all other technical aspects, for any project participating in the development of dignified and respected people. In this way the people are recognized from the beginning as equal partners and not as receivers on whom ideas and concepts are imposed which may worked in another context. This time demanding, often frustrating process, is central to a holistic development project.

3. Present Conditions in Humla

Humla family: No light, No cooking stove

Every home in the remote and high altitude villages in Humla, uses fire wood in indoor open fire places for cooking, heating and light. Women and children are most likely to suffer from the enormous indoor smoke pollution[6], causing health effects, such as respiratory diseases, asthma, blindness and heart disease[7]. The constant deforestation results in a scarcity of local fire wood, and thus forces the people, mainly the women and children, every other day to spend up to 7 hours in gathering fuel wood further a field[8]. Thus it is understandable that women place a high value on improved energy services such as efficient cooking and heating stove and light, because as they are not only the primary users and organizers of the household energy, they are also exposed to the greatest health risks and work loads.

Lack of electricity and heavy reliance on traditional biomass are hallmarks of poverty in developing countries[9]. This is generally true for Nepal, and in particular for the mountain communities in Humla. No light and no stove in the home are often signs for general poor hygienic conditions of a family. That goes commonly together with no latrine and no access to fresh, clean drinking water. But after some awareness training through non-formal educational tools such as easy to understand brochures, colorful posters designed according to the peoples' context, as well as songs in their own local language, people understand quickly that that light in their homes, an improved, efficient smokeless metal stove for cooking and heating, the use of a pit latrine and access to sufficient pure drinking water, is not just desirable, but necessary for the healthy growing and development of their whole family and community.

[6] Open fire use create the PM_{10} levels ≥ 20,000µg/m3. US-EPA 24hrs average not exceed 150µg/m3 more than 3 times a year. Annual average not exceeding 50µg/m3, *Smoke, Health and Household Energy,* ITDG, September 2002
[7] IEA, *World Energy Outlook 2002*, chap. 13, page 367-8
[8] This agrees with data from India collected by UNDP (IEA, *World Energy Outlook 2002, chap. 13, page 366)*
[9] IEA, *World Energy Outlook 2002*, chap. 13, page 365

4. Available Renewable Energy Resources

Nepal has plenty of renewable energy resources, in particular water and sun energy. The country's theoretical potential has been estimated at 40,000-83,000 MW, second only to Brazil. Until the end of 2003, only 535 MW have been developed, and mostly from 1970 onwards[10]. The sun's free energy too provides an excellent local renewable energy resource, with an average solar insolation of 5.5 - 6 kWh/m^2 per day[11]. Responsible handling of these available renewable energy resources enable conscious and compassionate professionals in partnership with impoverished mountain communities to develop their living conditions in sustainable, and environmentally friendly ways.

Lighting is often the first use of electricity in a developing country, and people are willing to invest in home or village electrification, once they understood the potential health improvements, the increased possible education for their children, and the possible financial savings[12] for their families.

The solar photovoltaic (PV) technology is increasingly viewed as an important option, especially by governments in developing countries with a limited and poor national grid network. Also among policy makers, lending and sponsoring institutions, the solar PV technology enjoys a good reputation in regard to generating electricity, especially for rural elementary lighting purpose in developing countries and for remote and difficult to access areas. The technology has proven to be robust in developed countries under field conditions and is considered mature, with easy, simple to follow installation procedures and low maintenance needs for solar home systems (SHS), if installations are done professionally and are used according to their design.

In order to design a solar village PV system that will provide the expected energy service in form of light in reliable ways, over an appropriate life span, the following issues have to be known and kept in mind, in order to pay due consideration for the local context:

- The solar insolation (W/m^2) and irradiation (kWh/m^2 per day) for the location the solar PV system is going to be installed.
- The village's population, annual growth, its load distribution and load growth pattern.
- Define reliable, easy to install and to maintain components. Local developed and manufactured products, if they have proven to be reliable, are preferred.
- The least-cost solution has to be aimed for.
- The participation of all stakeholders in all project steps is crucial and important for ownership.
- Cultural appropriate training, hand-over and operation periods have to be incorporated.
- Minimal/no ecological impact during installation and operation have to be aimed for.

5. Kathmandu University High Altitude Research Station

Kathmandu University High Altitude Research Station in Humla

In order to design projects with these considerations in mind, in partnership with the local communities in the high altitude mountain areas of Humla, Kathmandu University and the ISIS foundation have built a high altitude research station. Here all the technologies applied in the village projects are beforehand thoroughly tested as part of research projects for students and faculty. The smokeless metal stove, two SK 14 solar cookers, a University designed solar water heater for high altitudes, the pit latrine, and e.g. the same solar PV

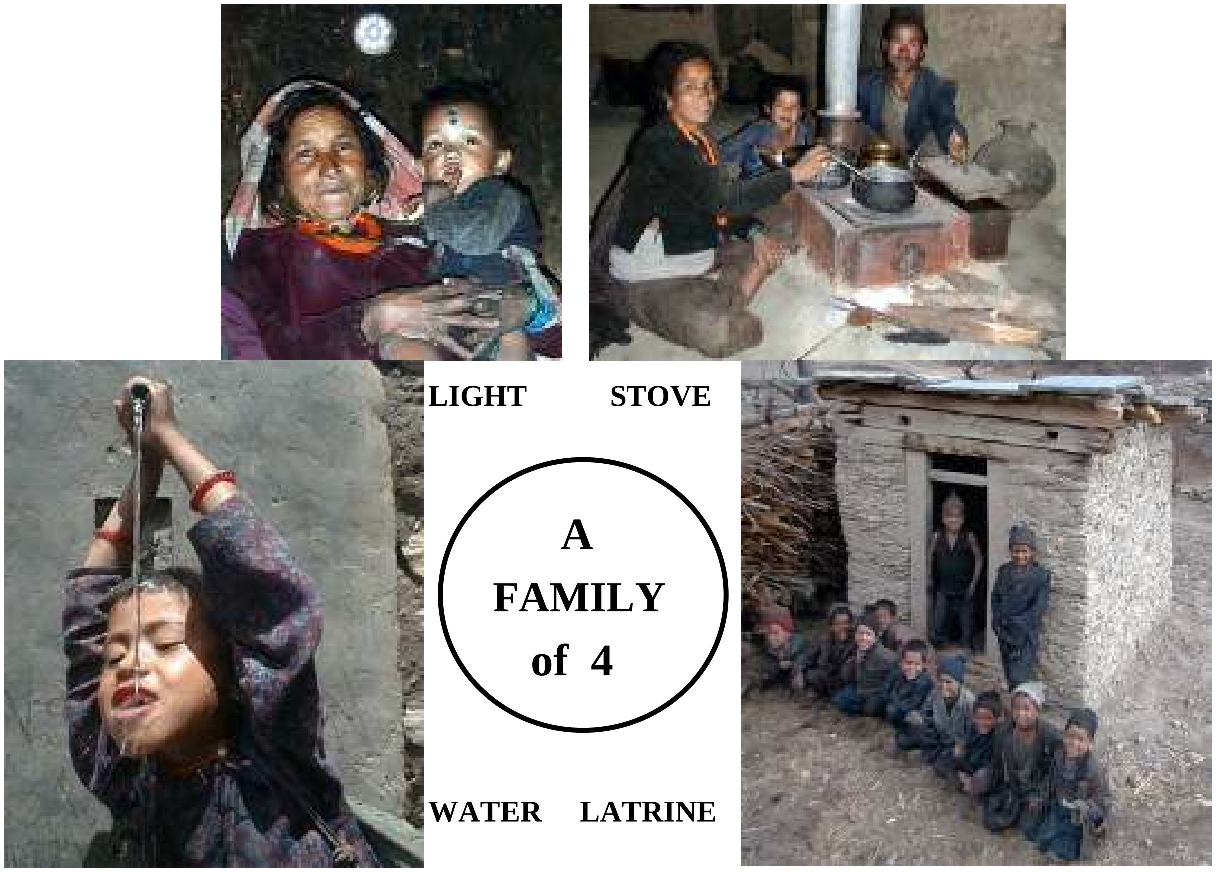
[10] "Medium Term Expenditure Framework – Electricity Sector", His Majesty's Government of Nepal, Kathmandu, www.ndf2002.gov.np/consult.html, [last accessed February 2004].

[11] NASA solar irradiation for Nepal, averaged over a 10 years time span from 1983-1993, http://eosweb.larc.nasa.gov

[12] E. Mills, and S. Johnson, *"A Dramatic Opportunity for Technology Leapfrogging in the developing World"*, Lawrence Berkeley National Laboratory, 2002 found that the approx. 2 billion people without electricity consume 96 billion litres of kerosene for household lighting, at a cost of US $ ~50 billion/year, with estimated emissions of 250 MT CO_2/year.

modules and self-tracking frames (see picture) are tested over an extended time at the research station. The incident solar insolation is recorded, resulting in daily solar irradiation data that enable a best possible starting point to design appropriate solar PV systems for neighboring villages.
Over the last 7 years, four issues have again and again been identified by the local people as their most urgent needs for their holistic and sustainable development.

Light – Smokeless Metal Stove – Clean & Pure Drinking Water – Pit Latrine



6. The Chauganphaya and Kholsi Village Project in Humla Nepal

Grown out of various successful student research projects a wider holistic community development project with the above mentioned approach and technologies, has started in June 2003. The two poorest villages in the near by area of the Kathmandu University high altitude research station have been chosen to become examples of holistic village development. In each home a smokeless metal stove, a pit latrine and 3 WLED lights are installed and each home will have access to pure drinking water through village drinking water system which taps into a natural spring. One of the two villages, Chauganphaya, has a centrally located 300 W solar PV system for its elementary WLED lighting system for its 63 homes (each home 3 WLED lights) while the other, Kholsi village, has a 1 kW Pico hydro power plant for its 60 homes (each 3 WLED lights) elementary WLED lighting system. As Kholsi's lights are only consuming a maximum of 250 W, it has additionally a warm water heating system with a permanent 700 W rod heater and a 300 W rod heater which is used according to the number of lights on or off, managed through an electronic load controller.

6.1. Chauganphaya Solar PV Village Project

Since the mid 90's the Nepal Government, financially supported by various INGOs (international non-governmental organisations) and international donor agencies, has run subsidised SHS (solar home system) programmes nation wise. This caused a mushrooming of new solar PV companies in Kathmandu, Nepal's capital. Today, the appropriateness and effectiveness of solar PV electrification is questioned in many rural places, as often SHS in Nepal have not performed as expected and not delivered what was promised. The price for a SHS is so high that subsidy programmes will have to run for decades to come. Further, there is not enough consideration for sustainability, maintenance and availability of spare parts such as lights, once they need replacement.

With the Chauganphaya solar PV system new ways are attempted in order to address these issues. A village centrally located solar PV system with four 75 W solar modules, mounted on a self-tracking frame to increase the daily energy output by up to 40%[13]. Underground cables connect each home from the centrally located powerhouse. This armoured cable is able to cope with a 300% power transmission growth in the years to come. Wires are not exposed to the high UV radiation (as in Nepal no UV stabilised insulation of the cables are available). Each home has 3 WLED lights, providing just enough light to read and socialise, making history of the strong smoking resin soaked pine wood stick lighting.

The WLED lights have an expected life of 100,000 hours[14] (or 45 years if used for 6 hours a day), making it close to unnecessary to be ever in need of a spare bulb. The PV system has a battery bank of six 100 Ah 12 V solar deep cycle batteries, which even after 3 days of no sunshine should be never more than 30% discharged, enabling them to have a life expectancy of 6-8 years. 3 special trained local people are responsible for the maintenance and monthly fee collection in order to maintain the whole system, afford any needed spare parts and to be able to buy a new battery bank after approximately 8 years.

6.2. What is the Expected Impact

To have light inside the home, means that inevitable changes are occurring. Rather than huge quantitative changes, primarily qualitative descriptive changes are expected, such as:

- Decrease in health problems: Less acute respiratory chest diseases, asthma, eyes infections.
- General increase in hygienic condition inside the home.
- Decrease in the use of the resin soaked pine wood, previously used for indoor light.
- Increase in the literacy rate and school children’s education level.
- Increase in social gatherings after dark, leading to improved relationships.
- Increased willingness and demand for non-formal education during the evening hours.
- Increased awareness for community development projects due to greater awareness.

In order to assess these qualitative changes also more quantitative over the course of the first year, a first survey was carried out before any community development work had taken place in December 2003. A second survey is going to be carried out after 6 months, in August 2004, followed by a third one 12 months after the initial installation of the solar PV system with the WLED lights, along side the smokeless metal stove, the pit latrine and the access to clean drinking water. These data will be able to either affirm or disprove the hypothesis, that the family of 4, light, stove, latrine and drinking water, will measurably improve the local peoples’ living conditions in regard to their general health, hygiene, education, social interaction and ability to take the responsibility for the development of their village more and more in their own hands.

[13] Measured at Alex Zahnd’s solar PV test station in Kathmandu.
[14] *The Led Light.com,* http://www.theledlight.com/technical1.html