THE ROLE OF RENEWABLE ENERGY TECHNOLOGY IN HOLISTIC COMMUNITY DEVELOPMENT

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Abstract

Recent research has demonstrated the direct relationship between poverty alleviation and improved access to clean, efficient energy services. Thus, improved access to basic energy services, such as a smokeless stove for cooking/room heating, basic electric indoor lighting, hot water for cooking/drinking/personal hygiene, have been recognized as a central part of an holistic community development (HCD) program. My experience of working with remote, impoverished high altitude mountain communities in Nepal since 1996 shows, that 80-85% of the local village communities identify the same four needs they wish to address: a pit latrine for improved hygiene/health, a smokeless stove inside the house for cooking/room heating/hot water, basic electric indoor lighting and access to clean drinking water. Thus I have developed the "Family of 4" HCD concept which includes projects, implemented in parallel, for each family of a village, addressing all four of these needs. Once the "Family of 4" projects are in place, and their impact and benefits are experienced, the local people start to recognize additional needs. Therefore, I created the "Family of 4 PLUS" HCD concept with thus far eight additional projects. Both HCD concepts address the millennium development goals (MDGs) directly. In the remote high altitude Nepal Himalayas, where the national grid and drivable roads will probably never go, these concepts have been shown to bring significantly more, long-term benefits than individual projects would have been able to. This is because the multi-faceted needs of the communities are recognised and addressed through a holistic, context-specific, multi-project approach, which produces synergistic benefits. Further, the HCD approach enables communities in such a unique and fragile ecosystem that is threatened by climate change, to adapt and become more resilient by tapping into their locally available renewable energy resources in sustainable, carbon neutral ways.

1. Introduction

Nepal is a unique country, in regard to its culture, people, geography, ecosystems and climate. These are crucial factors that must be understood in great detail when developing and implementing development projects (Zahnd 2012). Situated in the lap of the Himalayas, Nepal is landlocked between China to the north and India to the south, east and west. It embraces unique climatic environments, from tropical to high alpine, in a physical ecosystem, ranging between altitudes of 70 to 8,848 m.a.s.l. Previously cut off by thick forests and jungles, infested with malaria and dangerous animals, its culture developed for most of its history in isolation from any foreign influence. Thus it comes as no surprise that Nepal is still in its infancy in regard to its democratic political system, which started to take shape only in the 1990s. Further, frequent changes in the political leadership, with minimal long-term planning, as well as the decade long civil war from 1996–2006, has resulted in the decay of the urban infrastructure, so that it has become "acceptable" in the capital, Kathmandu, to live without access to electricity from the grid for 18-hours a day during the drier season of the year, from February to May. Nepal is one of the poorest developing countries, with 42 of Nepal's 75 districts considered acute and permanent food-deficit areas. Nepal is also one of a few countries with a lower female life expectancy than male (Zahnd 2012). Officially (Nepal 2001 census) 92 different languages are spoken by 103 distinct castes and ethnic groups. Most people in the mid- and high-altitude hill/mountain areas are subsistence farmers with little farm land, poor soil and harsh conditions, making a meagre living. Crops are vulnerable, with immediate consequences if natural calamities strike or weather patterns change.

The Nepalese are family oriented and most tasks and events are believed to be connected with the spiritual world. Fortune and misfortune are widely accepted as the result of fate. Fatalism proclaims that "one has no personal control over one's life circumstances, which are determined through a divine or powerful external agency" Bista (1991). Bista points out that the culture of fatalism is inherently unsupportive and in conflict with development and productivity. Approximately 80% of Nepal's population belong to the 2.4 billion people who rely on traditional biomass such as firewood, agricultural residues and dung, for their day to day cooking, heating and lighting purposes. The rich resources of Nepal, in particular the abundant water from over 6,000 rivers flowing from the high Himalayas down to the Indian sub-continent, and its abundant solar energy, with 300 sunny days per year, are underutilised. Thus most (~75%) of Nepal's rural people and communities are deprived of even the most basic energy services (Zahnd 2012).

Over the course of the last four decades many summits, conferences and seminars on "Sustainability and Development" were held (Zahnd 2012), and many theorists have come up with new definitions for "sustainable development". However, rather than clarifying the original meaning of each word and defining the practical outworking and implications of joining them, "sustainable development" is used today as buzz word which must be included in project proposals, otherwise donors will not even consider financing it. However, considering their original meaning in context it becomes clear that sustainable development emphasises the need to maintain the ecological balance while striving for social and political changes. Thus, a deep understanding of the local belief systems, cultural adherences, political history, poverty, status of development and economy (Zahnd 2012) are crucial for community development projects in Nepal. In addition, the environmental, technical, managerial and more philosophical issues form a basis for understanding and implementing community development projects.

This paper reviews the role of renewable energy technologies (RETs), designed for a specific context, to meet identified community needs. These RETs are embedded in the new HCD concepts "Family of 4" and "Family of 4 PLUS" (Zahnd 2012). Renewable energy technologies such as solar PV, solar thermal (water heating, food drying), pico-hydro power, small scale wind turbines and biomass (firewood) cooking and heating stoves, are considered within the context of implemented, village based, HCD projects.

2. Philosophy and Rationale of Holistic Community Development

2.1 A Glimpse at the History of Development

In the late 1960s and 1970s the social and economic climate was favourable for projects that emphasised holism, community, and social equality. It was axiomatic among community development professionals and theorists of development that projects should be holistic, multi-pronged, and involve the efforts of a multi-disciplinary team, acting in concert with local people. This was the climate out of which the Alma Ata conference in 1978 developed. In the early 1980s the world economy looked very different — economic recession, debt, the oil crisis and an increasingly unfavourable trade climate had taken their toll, and the world economy was not growing as hoped. Development projects across sectors had failed and many people had lost confidence in the process of international development. Health focused UN agencies (e.g., UNICEF) and the WHO were affected by heightening public scrutiny and criticism as well, and were increasingly governed by the need to show results that were simple to display, easy to understand, and obtainable within a defined funding cycle (often only 1-year). Due to this, plus greater emphasis by donor agencies on quantifiable results and outcomes, a more narrow definition of primary health care emerged and dramatically changed the nature of the projects that were promoted and funded. This definition is often associated with the somewhat contentious "selective approach", centred on short-term, single-goal-oriented interventions, and cost effectiveness, such as a vaccination, a drinking water or a literacy program. The scope of projects narrowed in order to meet ever tightening control over reporting and transparency, and an overwhelming need to show results – preferably within one fiscal year.

2.2 Comprehensive vs. Selective Approaches to Development

Thus, over the course of the last few decades, community development has mostly addressed individual issues and needs of projects' end-users, with often minimal interaction and participation of the receiver, resulting in minimal long-term impact and/or new opportunities for the beneficiaries. This is a consequence of the serious shortcoming of failing to recognise that communities have multi-faceted problems and needs within a defined environment and culture. Single-strand projects can never address these many-sided needs and issues, which are all dependent on, and interlinked with, each other. The various self-identified needs of the community have to be heard and included in a new, more holistic community development project approach. Today, most of the traditional health projects concentrate on curative health treatments, addressing sicknesses and health impairments caused by people's poor living conditions. While people treated under such projects get better over the short-term, they often fall sick again once they return to their homes and former way of life, because the root causes of their poor health conditions have not been dealt with. This widespread approach to development shows that there is a significant lack of understanding of the importance of preventative health care measurements and projects. Thus I claim that while selective approaches to development are effective in achieving carefully de-limited goals, selective approaches cannot produce the critical synergistic benefits of a multi-pronged, holistic project framework.

Currently, it is widely recognised that acute respiratory infections (ARIs), diarrheal diseases and malnutrition are the main problems that need immediate and sustained attention in rural Nepal (Winrock 2004, Pandey 1989). These problems cannot be addressed without making deep and significant changes to infrastructure and behaviour patterns. While selective projects targeting diseases like polio and measles are critical and do show results that are easily quantified, they cannot be the only approach to tackling the serious health problems facing rural people in the struggle for improved overall living conditions. The scope of solutions has to be as wide and as multi-sectorial as the identified problems that local people suffer. Thus respiratory infections can be addressed through a stove inside the homes, supported with solar PV or pico-hydro powered electrical indoor lighting, improving the cooking, room heating and indoor lighting conditions from the previous open fire place drastically over time. Diarrheal diseases can be countered through a family built and owned pit latrine, thus banning the open defecations that spread disease. Access to clean drinking water is facilitated through the village owned and built drinking water system, which pipes clean and fresh water from the community owned water source. Malnutrition, a very wide spread phenomenon, can mainly be addressed through increased hygiene awareness and non-formal education literacy classes, enabling the mothers to understand the reasons for their children's poor nutrition stage and often early, unnecessary death. Further, increased local food availability is achieved through high altitude greenhouses, which produce vegetables for 10 months per year, instead of the previous 3-4 months through the traditional farming technologies. These produce long lasting changes, leading to sustainable development after 10-15 years.

In our time in the villages, we have seen positive synergistic effects of HCD programs, when project components are chosen by villagers based on their needs assessment and when these components dove-tail together to improve the overall hygiene, sanitation and access to elementary energy services in the village. Thus, local context developed RET projects are embedded in long-term HCD activities and preventative health care programs that remove the root causes of poor health conditions. Two major, direct health related benefits, are experienced through RET projects. First, their application and use brings relief from suffering, related to poor living conditions, such as heavy indoor air pollution from open-fire cooking and heating. This enables improved overall health-, and living-conditions, even for people with permanent and incurable health conditions. The second, greater and long-term benefits of RETs, lie in the prevention of a whole range of illnesses and health impairments for the people born into families who already have an HCD implemented.

Fig. 1: The "Family of 4" consists of a pit latrine, a smokeless metal stove, elementary indoor lighting for each household and access for each family to clean drinking water from the village based tap stands.

The most commonly expressed needs communities address themselves are a Pit Latrine, a Stove, Basic Indoor Lighting and Clean Drinking Water. These all address improved and easier access to basic energy services, and better hygiene and health conditions. Thus I developed the new Holistic Community Development (HCD) concept of the "Family of 4" (a Pit Latrine, a Stove, Basic Indoor Lighting and Clean Drinking Water). Once the "Family of 4" HCD is implemented, in use and impacting on people's lives and living conditions, the "Family of 4 PLUS", with various additional measures is introduced (Zahnd 2012).

3. Holistic Community Development Concepts – “Family of 4” and “Family of 4 PLUS”

Some of the primary health conditions affecting people in the remote mountain communities are: scabies and other skin conditions, due to unhygienic living conditions; chronic and often severe upper- and lower-respiratory chest infections, due primarily to indoor air pollution from cooking over open-fires; gastro-intestinal worms and other parasites due to the lack of hygienic human waste disposal systems; and dysentery and Giardia infections from polluted drinking water. To address only one of these problems with a technical solution might be attractive to a donor with a limited mandate, time-frame, or budget. While recognising that limitations such as these are a reality for many donors, experience shows that a single-pronged approach is neither sustainable nor beneficial in the long-term. So I developed the “Family of 4” HCD concept (Figure 1), which is a set of innovations installed as a group in each home in a village. It includes a pit latrine, a smokeless metal stove, basic indoor lighting (through a locally available and utilised renewable energy resource such as solar, hydro or wind), and access to a safe drinking water system. The “Family of 4” HCD approach addresses the key features of village life which are responsible for primary health problems. The synergistic benefits of the components are consequently many times more powerful than individual projects, such as “just” light, or “just” clean water, or “just” better sanitary conditions when implemented alone.

Each of the pieces of equipment that we install is developed locally, bearing in mind the cultural, meteorological, social and economic contexts and the technical limitations of working in this harsh environment. For example, we needed to balance such considerations as the materials available in the villages to build the latrines, accommodating the heating needs and culinary preferences of local people in the design of the smokeless metal stove, the architecture of the houses in the design of the stove pipe, the amount of solar irradiation available in each village considered to be electrified with a solar PV system, and so forth. This level of detailed research, development and customising of technologies is part of what we call “contextualised” technology. It demands significant forethought and long-term commitment to working in the villages, “tweaking” the technologies as new demand or behaviour patterns evolve, and resources to put into baseline needs assessment and follow up research lasting for at least one generation (~10-15 years).

Fig 2: Alongside the efficient smokeless metal stove, designed for the particular local cooking culture and heating needs, also WLED lamps for minimal but locally appropriate, long-lasting light services, are installed in each home, as part of the “Family of 4” HCD concept.

Fig 3: The Smokeless Metal Stove (SMS) which I designed in 1998, has been continually improved. Up to the end of 2010 over 5,000 homes in the remote districts of Nepal have had one installed. It cooks the traditional food “dhal bhat” all at one time and “roti”, uses ~40% less firewood, provides appropriate room heating and 9-litres of hot water for drinking the local “butter tea” as well as facilitating an improvement in personal hygiene. This is called “contextualised” technology, with people, their culture and way of living in the centre and technology developed to suit them in their context.

An example illustrating how important it is to contextualise technologies comes from the development of the smokeless metal stove that we install in the Humla homes. What local people told me that they want is a cooking and heating system that allows them to prepare multiple dishes simultaneously, to produce the national dish called “dal bhat tarkari” (lentils, rice and vegetables) twice a day, whilst also warming the room in the winter. Humli people also like to eat a type of unleavened bread (roti) that has to be toasted in the embers to produce the desired taste. These demands are tough to manage on a single burner stove or open-fire place without an air flow regulation or exhaust damper, in order to control the combustion process according to the meal being prepared or the seasonal heating demands. In contrast, the smokeless metal stove I developed is designed to meet these preferences, with an easily adjustable air intake and exhaust pipe valve, 3-burners on which food can be simultaneously cooked, and a toaster-slot to toast *roti* in the embers (Figures 2, 3). All of these tasks can be accomplished without opening the front of the stove, which is critical, since operating a stove with the door open allows smoke into the room, and causes the combustion to flare out of control, increasing the rate at which firewood is consumed. Each of our stoves has a stainless-steel water-tank abutting one side, where water can be boiled and stored for drinking, washing, or other needs. Further, each stove consumes, if properly used, ~40% less firewood and has a unique number so that we can follow it up for years to come. This has proven important for quality monitoring and trouble-shooting.

In a similar fashion, basic electric indoor lighting powered by a solar PV system, is not the same for every village or home, through a standard solar PV system. Rather, a solar PV system is designed depending on a village's context in regard to its geography (exposure to the sun's daily path throughout the year), culture, demography, village cohesion and locally identified needs (which are in most cases basic lighting services). As these parameters vary from village to village so must the design of a solar PV system reflect the local context. My experience since 1996 shows that three different approaches to solar PV village electrification systems cater for the full range of villages in Humla. Thus I developed three different solar PV village systems, the Solar Home System (SHS), the Solar PV Village Cluster System and the Solar PV Central Village System. The SHS is for an individual, single home. It consists of a 16 W_R PV module, fixed on an aluminium frame, a charge- and discharge controller and a battery bank (14Ah capacity, 12V), which are both contained and protected in a sealed metal box. Each home has 3 WLED (white light emitting diode) lamps, consuming each 1 watt only. In Nepal the mountain communities often build their homes in clusters of 4-10 homes. Thus, I designed the cluster solar PV system to meet the needs of their WLED lamps. One 75 W_R PV module, mounted on a one-axis adjustable aluminium frame is installed in the middle of the cluster. A battery bank with a capacity of 100Ah, 24V, regulated and protected through a specifically designed and locally manufactured charge– and discharge-controller, provides the power for all WLED lamps of up to 12 homes, connected through buried underground cables. If a village consists of >25 households in close proximity to each other, it can be electrified through a centrally located 2-axis tracking solar PV system. A 2-axis tracking system, locally developed and manufactured, with 4 x 75 W_R PV modules can provide up to 60 homes with sufficient power and energy to illuminate each home with 3 WLED lamps for up to 5 days without sunshine. In a centrally located house, on whose flat mud roof top the 2-axis solar PV tracker is installed, is also the common battery bank (400Ah, 24V). Protected by a purpose designed charge- and discharge controller, the converted solar energy is stored and managed according to the village's load demand. The battery banks of all three different systems are designed in such a way that they can provide the needed energy for up to 5 days without sunshine, even at a minimum battery temperature of 10°C. However, battery banks are always kept in either a locally made wooden box, insulated with local pine needles or silver birch bark (central and cluster systems), or in an insulated metal box (SHS), in order to keep them always between 15°C–25°C. Besides the solar PV modules which are imported, all the other equipment has been developed locally and is manufactured locally, providing valuable new skills and jobs.

Further, in order to provide the best value, ability to repair, exchange or add additional lights, the WLED lamps were developed and are manufactured in collaboration with PPN (Pico Power Nepal), a local company. The WLEDs used are of high quality (Nichia NSPW510DS). A 12 diode lamp consumes about 1 watt and has a very long life expectancy of >50,000 hours (Zahnd 2012).

It is an essential part of the "Family of 4" program that each of the four "pillars" are continually developed, based on the ongoing learning of implemented projects and the resulting feedback of the end-user communities. Thus the various components of the "Family of 4" undergo ongoing improvements, based on monitored field research data and anecdotal end-user experience. With the "Family of 4" being implemented for each family in a village, the people experience positive changes over time. They become increasingly aware of additional needs they would like to have addressed for their family's/community's long-term development. Thus, once the "Family of 4" program has been running for about 2 years, the second phase, the “Family of 4 PLUS” program (Figure 4), can be launched. This program includes a wider range of identified needs, which can change from village to village, according to their circumstances and needs.

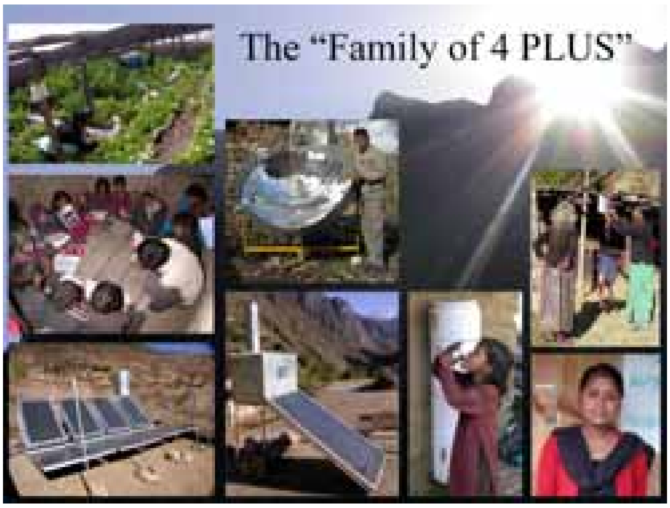

Fig.: 4: “Family of 4 PLUS” HCD concept, 8 additional projects to be implemented according to the local communities’ needs identification.

- Greenhouse for high-altitude villages.
- Non-Formal-Education (NFE) classes for mothers and out-of-school children.
- High-Altitude Solar Water Heating (HASWH) bathing centre.
- Solar Cooker for cooking during the day.
- Solar drier to dry vegetables, fruits, meat etc. for winter and income generation.
- Slow Sand Water Filter (SSWF).
- Nutrition program for malnourished children <5-years of age.
- Karnali Technical School scholarship for a 2 ½ years hands-on apprenticeship.

With 199 days of frost a year only 3-4 months of agricultural work is possible, the major reason why Humla has permanent food shortages with high levels of malnutrition, especially in children. A low-cost greenhouse was developed, using local stones, wood beams and UV stabilised plastic (Zahnd 2012). Six years experience and 35 greenhouses built in the local villages show, that it is now possible to grow vegetables during 10 months per year. Further, as part of a practical Kathmandu University student research project I developed a solar drier, in order to store the greenhouse’s product yields in clean and hygienic ways. The solar drier enables the drying and preserving of their precious foods for consumption in times of food shortage.

The rivers in this high elevation area are the warmest from June–August, measured at 12°C-16°C. The rest of the year they are between 4°C-12°C. Thus, water for bathing needs to be heated by wood fires, and wood collection is already a huge burden for women. Thus, through another Kathmandu University student research project, a commonly owned high elevation solar heated bathing centre has been designed and built (Zahnd 2012). The solar water heaters are designed and manufactured in Nepal, with hot water storage tanks and insulation to protect the system from freezing in the winter. One bathing centre unit, consisting of four flat plate solar absorbers and one hot water storage tank, allows up to 300 people to enjoy hot showers (calculated at 10 litres, 50°C water per person) once every two weeks, addressing the pressing need to improve local hygiene. A data monitoring system, recording the incoming solar irradiation, the intake water, the absorber, the hot water storage tank temperatures and the daily hot water consumption, provides in the two bathing centres built and running, valuable feedback for future improvements.

Though the villages with running “Family of 4” projects include a village based clean drinking water system, it is often the case that the drinking water gets contaminated by the way people store and handle the water in their home. Unhygienic conditions inside the home, attracting flies, rats, chickens and dogs, pose a potential danger of pollution to the drinking water. Thus, I developed through RIDS-Nepal an indoor Slow Sand Water Filter (SSWF) for the average household family size in the Humla district of 6 people (Zahnd 2012). The SSWF is filled with two kinds of sand, in order to first filter out the rough, more visual parts, before the actual biological process through the “Schmutzdecke” takes place in the main part of the SSWF. A 9 litre water tank, containing the purified water, is accessed by a brass tap. RIDS-Nepal’s ongoing faecal e-coliform tests have confirmed that up to 98% pure water can be achieved and maintained for consumption with and in the SSWF, which meets the Nepali standard.

We believe in the synergistic effect of a project such as our “Family of 4” and “Family of 4 PLUS” because we have seen individuals and groups (e.g., women) rally together in ways they never did before, and take a qualitatively different and new approach to problems facing them. For instance, the NFE-classes targeting women bring literacy to members of this community who have never previously been able to read posters or brochures with health messages.

With the “Family of 4” and “Family of 4 PLUS” approach as applied up to 2011 in thus far 16 villages, we have created project components that both stand alone *and,* especially in combination, energise villagers' faith in and enthusiasm for making changes in their village as a whole. It is easy for people to appreciate the benefits to themselves, their families, and the larger group from participating in such a project.

4. Project Planning and Evaluation Procedures

It is paramount for the new HCD concept of the “Family of 4” and the “Family of 4 PLUS” that before any project activities are planned a Base-Line Survey takes place in the community or village interested to work in partnership with RIDS-Nepal. Paying due justice to the nature of holism and people's multiple needs and ingrained desire for improved living conditions, the base-line survey has been developed by a professional task force. Thus an anthropologist, a medical doctor, a community development specialist (author) and an experienced project implementer (a RIDS-Nepal field-manager trained by the author) put their heads and experience together and over the course of a year developed a 56 question Base-Line Survey questionnaire and 52 question Follow-Up Survey questionnaire. Starting with more general, household, social and economic status related questions, the questionnaire also asks each household of the village or community some demographic, social/attitudinal and health questions. The questions related to the major health conditions and diseases of the people in this area, are asked by professionally trained health staff of RIDS-Nepal. The whole survey is conducted with the greatest care and sensitivity for the people's privacy and right to remain silent. Each RIDS-Nepal staff member participating in such a survey is trained on how to conduct the survey, how to ask questions, how to “read between-the-lines” of the answers provided and how to fill in the blanks. It is compulsory that the questions related to family planning and women's issues are asked by RIDS-Nepal female staff and that each person participating and volunteering with their answers in the survey can remain anonymous if they wish to. This base-line survey enables a detailed quantitative and qualitative understanding and perspective of each family in a village and a village as a whole. It allows the local people, who will be the end-users of any development activities taking place in the time to come, to be the main informants and data providers. They are able to identify, probably for the first time in their life, their own status living conditions within their village, and their perceived needs which they consider to be important to be addressed. It provides RIDS-Nepal, as the local people's most direct partner, as well as all the other stakeholders of the forthcoming projects, with a picture of the local context, situations and identified needs.

With all the information and data in hand, mutual discussions and meetings among all the stakeholders take place, during which the actual scope of a project is developed and agreed upon. This whole process, from the initial base-line survey, is often very time consuming and can take up to one year before a mutual agreement between all the main stakeholders, the local people, RIDS-Nepal as the NGO partner and the donor agency, is signed. Once agreed and signed by all parties, the actual long-term program, starting with the “Family of 4”, is launched. The various training programs provided for the local people/families and community representatives and the implementing of the “Family of 4” projects usually takes 1-2 years. Thus, after 2 years, the “Follow-Up Survey”, with slightly adjusted questions compared to the base-line survey, takes place. This allows the gathering of quantitative data as well as anecdotal, qualitative information through the feedback from those who participated in the implementation of all the “Family of 4” projects. They would have already experienced the direct impact over the last 1-2 years of their pit latrine, smokeless metal stove inside their home, the elementary indoor lighting and the availability of clean drinking water from the village water tap system.

It is part of the long-term HCD concept of the “Family of 4” and the “Family of 4 PLUS” programs that such a follow-up survey is carried out in the 2nd, 5th, 10th and 20th years of the project. In this way a dynamic, ongoing evaluation of the whole HCD program can take place. Every follow-up survey provides ample food for thought, resulting in alterations and improvements of the long-term HCD program. Further, the collected data/information demonstrates the impact the projects have had thus far. The new HCD concept has a timeframe of two generations or ~20 years in the context of Humla. This allows for such a new development approach to become accepted by the local users and eventually to become part of their indigenous culture.

While each of the “Family of 4” and the “Family of 4 PLUS” projects enables life changing improvements, they do support and enhance each others' impact and thus benefit the local end-user community. But it is extremely difficult to measure the extent of the synergistic benefits that this new HCD concept sets in motion. Further, in order to identify synergistic benefits on living conditions requires not just a few weeks or months, but rather years. Thus, time, in the sense of long-term participation and monitoring, needs to be taken into consideration as a crucial parameter. Not only are factual data with regard to synergistic benefits very difficult to obtain, they are also difficult to track retrospectively, particularly in regard to their source, magnitude and quality. This is because most benefits are related to long-term improvements in living conditions and increased preventative health care from the various, concurrent projects and these changes are hard to identify and express in mere numerical terms. However, some of the shared end-users' anecdotal testimonies include the following:

- Since the SMS has been installed the women and children of the homes have been freed from their chronic coughs and chest pains as well as their previously persistent eye infections and heart pains.
- The pit latrine each family has built as a pre-condition for a SMS has enabled the whole village to become much cleaner and more hygienic.
- The people, and in particular the children, experience far fewer cases of diarrhoea with the consequent dehydration, loss of valuable nutrients, subsequent weakness and inability to work or learn.
- These improved health conditions, in combination with the basic indoor lighting with WLED lamps powered by the locally available renewable energy resource (usually solar- or hydro-power) as the third pillar of the "Family of 4" HCD concept, enable the women and out of school children to participate in the daily NFE-classes.
- To be able to read and write, along with the basic numeric skills, brings invaluable long-term personal as well as community benefits, which would have not been possible without the HCD approach.

In addition to the Base-Line and Follow-Up Surveys, which measure the initial status and the ongoing improvements of people's living conditions during HCD programs, we monitor in great detail selected project parameters, such as the performance of solar PV home/cluster/village systems (Zahnd 2012). This is done because it is quite common to read in evaluation reports of solar PV home/village projects that they are not able to provide the energy services expected by the end-users, nor achieve their projected life expectancy. Long-term monitoring of solar PV systems in their installed context, the analysis of their detailed performance over time, and local seasonal shifts is almost unheard of, especially in developing countries. The vital information gained through monitoring is essential to understand and improve a system's actual field performance. This leads to more appropriate system design, considering the local context in regard to the prevailing meteorological conditions and energy service demands. Since 2006, we started to monitor the performance of various solar PV systems (single home/cluster-/central systems), a pico-hydro power village system, and high altitude greenhouses. Each system is monitored in great detail by a carefully designed data monitoring system. A databank developed by RIDS-Nepal, with all the data from 11 data monitoring systems has been made available for registered users through the RIDS-Nepal web site.

5. Results and Discussion

To evaluate, assess or measure the impacts on, and changes to the lives and environment of the people through implemented projects, be it in quantitative or qualitative terms, is inherently difficult. This is because mere numerical values cannot comprehensively explain the effects a project has upon a person's health, living condition and environment. Further, the situation becomes even more complex if a holistic community development approach is followed, such as the multi-pronged "Family of 4" HCD concept. In this case each individual project has a direct and indirect influence on each other, as well as enhancing the overall outcome and results through synergistic benefits. The Base-Line and Follow-Up survey questionnaires that RIDS-Nepal uses (Zahnd 2012) attempt to take these interactions into account. Examples of health and attitudinal impacts and changes, produced by HCD village projects, are presented below (Zahnd 2012). These results are obtained from the analysis of the Base Line Survey and Follow-Up Survey (1-2 years later).

- Approximately 40% reduction in firewood consumption and 7% reduction in firewood collection time have been achieved by the users of the new smokeless metal stove. The small reduction of firewood collection time indicates, that while the stove technically provides a significant improvement, the wide spread deforestation demands that the bulk of firewood collection time is spent in getting to the forest and not the actual firewood collection.

- The benefits for families of building and using a pit latrine (PL) were demonstrated by an average reduction of 20%-60% of people (dependent on age and gender) suffering from intestinal infections (such as diarrhoea) and intestinal worms following the implementation of the "Family of 4" project.

- People seem to feel less stress and see things more "positively" with regard to their resources (+70%), education (+550%), health (+500%), relationships and "general life outlook" (+660%), once an HCD program is implemented.

- There is a great need for increased awareness raising and education among the end-users of community development projects in regard to what community development is, what it aims to do and the realistic changes it can produce.

- Particulate Matter ($PM_{2.5}$) and CO (Carbon-Monoxide) 24-hour Indoor Air Pollution (IAP) Measurements show that health endangering $PM_{2.5}$ and CO values can be significantly reduced through the installation of an SMS (by 10-50 times and even more for CO).

- Respiratory ailments are particularly common among the people in Humla, due to open-fire place cooking and heating and the use of "jharro" for lighting (local resin soaked pine tree sticks which are burned to generate a dim and smoky light). The results of installing the SMS and indoor WLED lighting show that the trend is encouraging, with fewer people suffering from respiratory ill health (Figure 5).

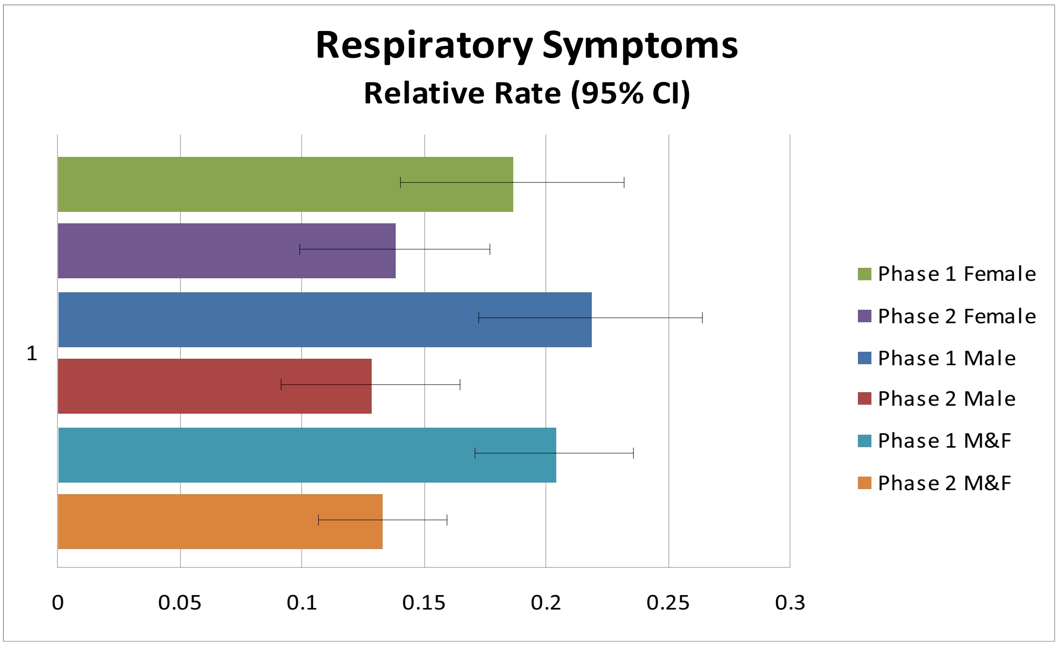

Fig. 5: Respiratory Symptoms: Prevalence Rates before (Phase-1) and after (Phase-2) the "Family of 4" project, with 95% Confidence Intervals

- Another encouraging piece of anecdotal evidence is that people who have participated in the implementation of a "Family of 4" HCD project became increasingly aware and able to identify additional needs for development. They include the need for increased education (literacy, numeracy, technical, +55%), increased application, use and maintenance of contextualised technologies (mainly renewable energy technologies +63%), and increased business activities (e.g. selling vegetables grown in local greenhouses, +77%). This led the author to develop the "Family of 4 PLUS" HCD program, which is a more flexible, long-term program including various additional projects.

Thus, the data gathered and interpreted so far show very encouraging outcomes and results. However, these data represent changes after only ~2 years of a "Family of 4" HCD program in the villages. With HCD programs aiming to continue (including their follow-up) for up to 20 years, their impact is expected to become increasingly greater.

The centrality of RETs in HCD projects is illustrated by the following example of the comparison of different long-term impacts of solar PV powered WLED indoor lighting with the traditional fuel based lighting called "jharro" as practiced by the Humla people. The data shows that WLED lighting not only improves the quality of lighting, but also the general living standard of the people over time. WLED lighting helps to improve their health, education, life expectancy as well as income generation, resulting in a notable improvement of the United Nations' Human Development Index (HDI) factor for the community. The average life expectancy of Humla people is 54 years (KIRDRC 2002), resulting in a life expectancy index of 0.483. With an average adult literacy rate of 18% (women 4.8%, men 31.2%) and an estimated gross enrolment of 33%, the combined education index is 0.230. In Humla the average per capita income is US$72 (KIRDRC 2002), derived mainly from selling firewood and trading goods between China, Nepal and India. As more than 95% of families in Humla are farmers, an additional estimated annual US$40 value from their annual crops can be added. Thus the GDP index factor is calculated to be 0.019. When combined in the HDI formula the index for the Humla people, before any HCD interventions is 0.244 (Zahnd 2012), compared to the national average of 0.428 is indicated by the UN (UN 2010).

$$HDI = \tfrac{1}{3}\left(Life\,Expectancy\,Index\right) + \tfrac{1}{3}\left(Education\,Index\right) + \tfrac{1}{3}\left(GDP\,Index\right)$$
$$= \tfrac{1}{3}(0.483) + \tfrac{1}{3}(0.230) + \tfrac{1}{3}(0.019) = 0.244 \qquad (eq.1)$$

In order to utilise the synergetic benefits that elementary indoor electric lighting can provide, each electrification project RIDS-Nepal is implementing in Humla is part of a long-term HCD project, such as the "Family of 4". Based on a long-term HCD project, including WLED indoor lighting, the following HDI index changes over a ten year time span, compared to the unchanged neighbouring villages, can be expected (Zahnd 2012). The installed WLED lighting instead of the "jharro", in addition to the installed smokeless metal stove for cooking and heating, enable clean indoor air. PM_{10} (Particulate Matter less than 10μm mean diameter) measurements in traditional houses in Humla since 2006 showed that over a 24-hour time span, the average indoor air pollution was 10-50 times less with WLED lighting and a smokeless metal stove compared to the use of "jharro" for lighting and cooking on an open-fire place. These improvements over a 10 year period of time will produce considerable health benefits, especially in regard to chronic respiratory chest diseases. It is assumed that this will increase life expectancy by about 10 years, from the present 54 to 64 years. Thus, the "healthy and long life" HDI factor increases from 0.483 to 0.650.

Non-formal education classes for adults and out-of school children are part of the RIDS-Nepal HCD projects in Humla. The installed WLED lighting provides clean and smoke free light to enable people to read. That means that one of the synergistic benefits from the WLED lighting is that the educational level of the villagers is likely to significantly increase over the next 10 years. Also the number of children enrolling in school will increase substantially, once the mothers are aware of the changes education brings to their village and lifestyle. It is therefore realistic to assume a doubling of the literacy rate and school enrolment over a ten year time span. Thus, the combined "education" HDI factor increases from 0.230 to 0.460.

Adequate lighting inside the home provided by WLEDs, clean indoor air due to the use of a smokeless metal stove, a pit latrine, access to clean drinking water, all produce synergistic benefits. The increased social gatherings in a more comfortable environment bring forth new ideas for community and income generation activities such as knitting, bamboo basket weaving and other simple handicrafts. Thus, WLED based lighting allows an increase in home based income generation abilities, supported by better health and educational status, but compared with the first two HDI indices, it may not be the major factor. Thus it is reasonable to assume a 40% increase of the annual income can be achieved over 10 years as a result of indoor lighting improvements, which means that the GDP HDI factor can increase from 0.019 to 0.075.

Summing the three newly calculated HDI factors increases the overall HDI index from 0.244 to 0.395, an increase of 60% over the assumed time span of 10 years. This expected increase in the HDI index shows that replacing fuel based lighting with WLEDs, in combination with other related community development projects, can substantially improve the socio economic development of the communities. Follow-up survey and anecdotal data from RIDS-Nepal's implemented "Family of 4" HCD programs show that a 60% HDI increase is realistic (Zahnd 2012).

A point, often not strongly enough highlighted, is that the newly developed HCD concepts, which include various new locally manufactured technologies, are an important part of the slow, but steady growth of the local economy. The locally developed RETs provide a basis for industrial development and the creation of employment within the country. While accurate numbers are impossible to obtain, I have estimated that 300 new jobs (Zahnd 2012) have been created through the various new RETs (various solar PV systems, solar water heaters, solar drier, pico-hydro power plant, smokeless metal stove, slow sand water filter), that I developed through RIDS-Nepal and Kathmandu University and are now manufactured in Nepal.

6. Conclusions

Poverty has many faces, and cannot be defined simply by economic values and figures. Lack of electricity and heavy reliance on traditional biomass are hallmarks of poverty in developing countries (IEA 2002). One clear way to improve upon this situation is to work toward providing people living in poverty with access to, and control over sustainable energy projects, as it is widely accepted (Zahnd 2012), that "poverty alleviation and development depend on universal access to energy services that are affordable, reliable and of good quality" (Reddy 2002). There are clear linkages between access to energy and reduced infant mortality and increased literacy and life expectancy (WEA 2000). This further substantiates the assertion that applied RETs must take a central, crucial role in community development projects.

Deforestation in Nepal is widespread and the once picturesque and bio-diverse forests and valleys have been stripped of their valuable resources in unsustainable ways. Tapping into locally available renewable energy resources to provide the needed energy services provides the local ecosystem with a chance for recovery and results in synergistic benefits. The approach embraced in this collaborative effort between RIDS-Nepal, its donor partners and the local people, is that the combined outcome of a comprehensive community development project bears more sustainable benefits than a set of individual projects. This is particularly true with respect to the four critical pieces of community development technology in remote Nepal: pit latrines, stoves, lighting and clean water, which I called the "Family of 4".

Nepal has no fossil fuel resources, but is rich in renewable energy resources such as hydro-power, solar energy, as well as wind energy and biomass (Zahnd 2012). These abundant, locally available renewable energy resources, tapped into with locally developed technologies that the community has helped to specify and adapt to the local conditions, are one of the principal tools for development. Also, local applied RETs enable a community to become energy independent of any external providers. Further, a RET system contributes to the solution to global warming by making remote communities carbon emission free or neutral in the case of a biomass based energy system. This is worth mentioning, considering the rather fragile and unique environment of the Himalayas.

Some important lessons that I learned from previous unsuccessful RET systems that failed to provide the promised energy services, are summarised below:

- The locally available renewable energy resources have to be understood in terms of quality and quantity in regard to their minimal/maximum/average power capacity and seasonal availability.
- The local power/energy user(s)' geographical, social and cultural context has to be understood in detail, in order to decide which RE resource(s) to tap into and which RET(s) is/are most appropriate to provide the defined energy services for the project's whole life cycle.
- For the local context, relevant RETs have to be developed and applied, with a mandate for high sustainability, minimal losses, down-times and maintenance requirements.
- The use of locally available equipment and materials in the RET designs are more important than aiming for highest efficiency and the latest technologies.
- For the local context, appropriate educational and practical skills, O&M training programs for the local end-users of RET projects have to be provided, in order to achieve sustainable development. Maintenance and follow-up schedules have to be planned and incorporated into the project.
- Established lines of communications between the end-user(s) and the RET project implementer/equipment provider have to be in place for unforeseen problem solving/support as well as for programmed maintenance, follow-up and overhaul work.

- RET projects have to aim for financial independence from external funding during their life cycle. This is a difficult goal and in the places RIDS-Nepal is working the local communities are so poor that this goal is hard to achieve even over two generations.
- Professional engineering and design are mandatory in order to meet the energy service demands of a community with minimal loss of load, throughout a project's life cycle.
- Funding sources and management plans have to be in place during the detailed project planning for timely equipment replacement, RET system expansion possibilities, salvage values, decommissioning and possible recycling costs.

Without the technical components of a HCD program, the needed changes can not take place. Energy and effort has to be invested into the design, development, implementation and monitoring of the projects. Sound engineering principles, in the context of an understood cultural context of the end-users, are mandatory in order to develop appropriate, contextualised designs of technologies. Likewise, the building and maintaining of relationships among project stakeholders is also important and takes effort, time and investment.

Consequently it can be said that for communities with ample renewable energy resources such as the high-altitude villages of Nepal, contextualised RETs do play an important, central role, within a long-term HCD program, in providing the people with an opportunity to escape the vicious cycle of poverty. Improved health conditions, hygiene, increased food availability and nutrition as well as re-growth of their local biomass resources are all benefits the people directly experience in their family units and local community. Further, the local RET power plants empower the community towards energy independence and security.

Likewise, it can be strongly affirmed, that a multi-sectoral HCD concept for community development, as applied through the "Family of 4" and the "Family of 4 PLUS", is able to effectively address the multifaceted needs identified by the local people. A reductionist approach clearly cannot address the needs of a disadvantaged community as effectively as the HCD concept can. If the benefits of the HCD concepts of the "Family of 4" and the "Family of 4 PLUS" have to be summarised in one sentence, it could be: The whole is greater than the sum of its parts.

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