Pico-hydro Power Plant for elementary lighting as Part of a Holistic Community Development Project in a remote and impoverished Himalayan Village in Nepal

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1. Introduction

Nepal, with a population of 28.5 million (CIA 2007), is a developing country that UNDP ranks 138th of 177 countries using the Human Development Index (UNDP, 2006). 40% of Nepal's population are aged 15 years or less, and ~ 80% of the population live in rural areas that are difficult to access. With an estimated US$1500 GDP per capita, Nepal ranks 197th out of 225 (CIA 2007). Contrastingly, UNDP ranks Nepal as 68th out of 102 developing countries with an annual GDP per capita of US$252 (UNDP, 2006). The difference between these two estimates shows how difficult it is to describe the state and condition of Nepal using conventionally available data. The authors' practical experience has also shown that urban Nepalis earn multiple times more than people in rural areas, and that there is no, or just minimal, cohesion between them. Even in the context of this diversity of living standards, Humla, our project site, stands out, with a per capita GDP of only US$72 (KIRDRC 2002). In terms of energy, traditional fuel (biomass) consumption in Nepal represents 93% of total usage nationwide, and 100% in the remote mountain areas such as Humla. With an average annual per capita electricity consumption of only 91 kWh, accessible only to about 25% of the nation's population, Nepal ranks very low globally in terms of the population's articulation with the grid. Infant mortality, compared to developed nations, is high, ranging from 86 to 53 per 1000 live births for the poorest and richest 20%, respectively. Humla district is known as a permanent food shortage area and ISIS/RIDS-Nepal's surveys agree with the Humla District Development Plan's (HDCP 2003) estimate that 65% of Humla's children under five years of age are malnourished.

Figure 1: 150 villages are spread throughout the remote, high altitude Humla valley. They are isolated from the main stream development of the country.

Figure 2: Open fire place cooking and heating, signs of poverty.

2. The Need for Holistic Community Development (HCD)

It is shocking that such alarming conditions are the reality for millions of people in the 21st century. Billions of dollars are spent every year by governments for development, whether via bi-lateral aid agreements or donations to individual projects. And the results of this outpouring of aid are mixed. In 2000, the UN defined the MDG (Millennium Development Goals) in order to tackle the enormous gap between the developed and developing countries. The eight MDGs are a blueprint agreed to by all the world's countries and many of the world's leading development institutions, aimed to be achieved by 2015. Midway through this timeframe, most of the eight MDGs seem to be more off-track than in 2001. Many of the anticipated results are not in sight, and may not be reachable in the near future. This dilemma causes us to ask whether the MDGs, and the timeframe set for them were ever realistic and achievable. We agree with many development professionals who believe that our inability to substantially progress toward the MDGs is a result of the fact the present usage of most development aid is seriously flawed. We would argue that a fundamental a paradigm shift now needs to occur throughout the development industry.

Our experience working in the trenches in the field of holistic community development would instruct us that the MDGs were not achievable in the set time frame, because they were defined primarily by professionals who had never been exposed to, or lived among the people experiencing the realities the MDGs were designed to change. The anthropological insight and practical experience we have gained over the last decades makes clear that individuals', communities', even whole districts' or regions' lack of dignified human

living conditions cannot be addressed with one-off, single-pronged, results-within-a-fiscal year types of projects. We would argue, like many before us, that development efforts must be designed from the bottom-up, grassroots level, according to the end users' perception of their most urgent needs, rather than according to a donor's development agenda. This is not a new concept, and, for the field of international development in the health sector, was well developed and quite adequately articulated at Alma Ata in 1978. Developments in foreign aid around the globe since then have dramatically shifted project design away from comprehensive and grassroots approaches and toward selective, single-pronged projects designed from the top-down, which we would argue have undermined the efforts themselves as well as people's faith in the overall endeavor. But people's concerns, needs and problems are never simple, nor simply solved. All human needs are couched in complexly nuanced physical, social, mental and spiritual environments, . Issues to address in development projects must always be understood, discussed collaboratively and analyzed in the specific context of the ultimate beneficiaries. By definition this means that project planning should always unfold collaboratively with the target community and that the planning process honors and fits as comfortably as possible within local traditions, beliefs, and behavior patterns, as well as the geographical and climatic context.

Poor and marginalised people are often deeply trapped in the vicious circle of poverty, affecting the physical, social, and mental well being of every individual. We have developed a Holistic Community Development (HCD) approach for the people and communities living in the remote, impoverished Karnali region of Humla, in the north-west Nepal, some 17 days walk away from the next road. The conceptual basis of the HCD projects is that various needs, identified by the target population, cannot be addressed simply using a single pronged approach. Rather, the primary, interlocking health and resource-dependent needs identified by individuals in the community, have to be addressed in a comprehensive, multi-pronged approach. We do not aim to solve every imaginable issue facing the communities with which we work, but we work to help villagers articulate their primary needs and to design projects that efficiently, sustainably, and holistically address them. For instance, we install small scale electricity projects to benefit human health (reduction of indoor pollution) and the environment (reduction of usage of biomass). But only attending to this one piece of the overall picture means that other critical needs are neglected, such as indoor air pollution from open fire cooking and heating, and the lack of a human waste removal system, and contaminated drinking water, so that the lights we installed will be of marginal benefit to the end users. Potential health benefits resulting from the new lighting system could not be clearly demonstrated, since other important disease causing factors were left untouched. This undermines the faith of the villagers in the rationales we use to explain the benefits of the new technologies or their purported improvements to health outcomes. In other words, the health and resource- conserving impacts promised by the new sustainable electrification system, as wonderful as that system may be, could not possibly be realized, or perceivedin the absence of changes to other practices in the community.

Our work relies upon our combined experience of more than 20 years living, working and implementing development projects in the poorest and most remote mountain communities in Nepal. In addition to the value we place on the holistic approach to community development projects targeting health outcomes, we have also learned about the importance of relevance, cultural milieu, and in project planners and implementers spending time living in the target community. The amount of the time shared living with local end-users or beneficiaries to the development effort doesn't necessarily have to be protracted. But it is critical for project planners and implementers to have a solid sense of local behavior patterns, social hierarchies, expectations of the development effort and barriers to success. For instance, a smokeless stove project that pre-dated ours in Humla installed a type of stove that used more wood than an open fire, cooked one instead of the preferred three pots at a time, and routinely caught hay stacks on fire due to the placement of the smoke pipe. Not long after the implementation stage of that project, those stoves were scrap metal or used as counter space. In contrast, despite the time and effort required, our projects are developed in close partnership with the local communities, using their ideas for modification and improvement, and collaboratively implemented to foster a sense of ownership and overall "buy-in" to the project effort itself. Hard experience has taught us that there is no short-cut to sustainable and appropriate development. Living with the people targeted by the project, and learning to understand and respect the logic behind local culture and ancient tradition is crucial to the relevance of any HCD project. In an earlier latrine-installation effort, we were initially flummoxed by the fact that despite the appearance of abundant open space in which to place the latrines, no villager seemed to believe their household could afford the space for a latrine. The logic to their protestations slowly emerged – that piece of land was inhabited by a spirit that could not be polluted; another was the subject of a 3-generation old dispute over ownership; a third was too close to rice, a sacred crop, not to be contaminated by proximity to human waste. These nuances cannot be learned from books nor downloaded from the Internet – and without patience and a deep respect for local people and their perceptions of reality, can develop into complete impasses, or projects that quickly unravel after the implementers depart for the capital city. Real life experience has to be the basis for context-relevant, respectful and dignified sustainable development.

So our experience – with success and failure alike – was the basis for the HCD concept called "The Family of 4", which we are now implementing through the locally registered NGO RIDS-Nepal (www.rids-nepal.org) in close partnership with the local communities.

3. The Family of 4

While living and working with local communities, we experienced time and again that villagers defined their most urgent, regular household needs as: minimal electric light inside the home, a smokeless stove for cooking and heating, a toilet nearby the home, and clean drinking water accessible in the village for every person. This is how the "The Family of 4" concept came into being. The “Family” is a set of innovations that are installed, as a group, into each home in a target village, and includes a smokeless metal stove, solar lighting, a pit latrine, and access to a safe drinking water system. Common and easily treated conditions prevail in the target communities, and render life in this already challenging biophysical environment to be utterly miserable for many villagers. 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 lacking human waste disposal systems, and dysenteries and giardia infections from polluted drinking water are some of the primary conditions affecting people in the remote mountain communities where we work. To address only one of these problems with a technical solution (e.g., installing latrines but no safe drinking water system) might be attractive to a donor with a limited mandate, time-frame, or budget. While we recognise that limitations such as these are a reality for many donors, our experience has taught us that a single-pronged approach is neither sustainable nor beneficial in the long-term. The lure of the single-pronged approach – its simplicity, the possibility of completing the project within a single fiscal year for results to report back to the donor, and so on – must be resisted. The Family of 4 HCD approach addresses the key features of village life impacting the primary health problems described above. It thus deals with improvements to local people's living and health conditions from a much wider, holistic platform. The synergetic benefits of the components of The Family of 4, implemented alongside each other, are many times more powerful than if individual projects, such as "just" light, or "just" clean water, or "just" better sanitary conditions are implemented alone.

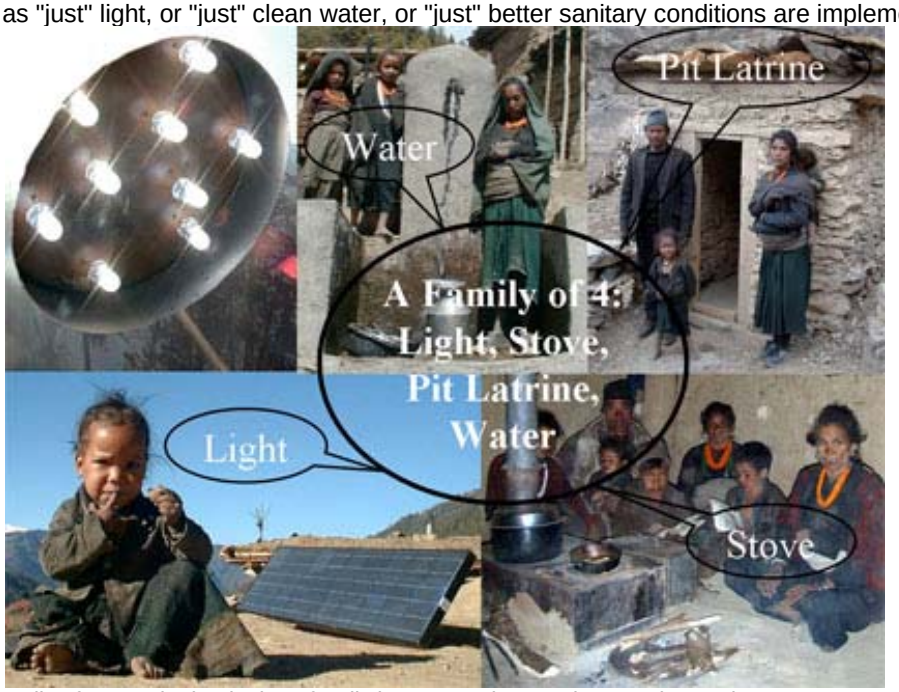

Figure 3: The "Family of Four", the beginning of Holistic Community Development in Humla.

4. One of "The Family of 4" Pillars - Electric Indoor Lighting through a Pico Hydro Power Plant

As described above, any rural village electrification, in order to be relevant and sustainable, needs to be embedded in long-term holistic community development projects addressing the basic health issues facing a community. The scope of this paper does not permit us to discuss each pillar of the "The Family of 4" approach (though the approach as a whole is discussed in Zahnd & McKay 2005A). In this paper, we focus just on one pillar of the "The Family of 4" concept: indoor electric lighting.

With no grid connection in sight for decades to come, the communities in Humla need to tap their locally available renewable energy resources. In the target village for this project, water flowing year-round in a nearby stream plus an average of 5–6 kWh/m^2 per day of sunshine provide great resources for an elementary RAPS (Remote Area Power Supply) system to provide minimal indoor lighting services. In order to understand the local population’s need for indoor lighting, we first attempted to understand how homes were lit previously and what activities occurred in homes after dark. In Humla, all families traditionally use *jharro* to light indoor living spaces. *Jharro* is a resin rich wooden stick from a high elevation Himalayan evergreen whose flame provides very smoky and minimal indoor lighting. Keeping this history in mind, our view was that it was inappropriate to plan and design an electrification system for this context using the

conventional approach -- 100 watt power consumption per family using the 150 year old, incandescent light bulb. We concluded this despite the fact that this is the approach to indoor lighting that is conventionally pursued in Nepal and elsewhere. Such a project, for a remote and impoverished area like Humla, cannot be sustainable from the perspective of the sheer amount of equipment and machinery that would need to be air lifted and then carried by porters into the village. Additionally, the initial project costs and the ongoing maintenance costs would be far beyond the local community's economic capacity, making this approach infeasible, even unfair for local people. Example after example in development projects worldwide have shown that local people have to grow into technological and subsequent behavioral changes slowly, for the simple, and perhaps obvious but rarely admitted fact that traditions and cultures change much more slowly than new technologies can be introduced. Thus we would argue that this needs to be a basic rule for any HCD project. Project planners, in collaboration with local people, have to understand and openly discuss the local cultural milieu, attitudes toward change and the various factors that may predict the ability of each householder to accept and integrate new technologies into their daily lives. The first time that an electrification system is introduced into a community, we believe that a step-by-step approach needs to be taken, starting with minimal, low level energy services, initially providing indoor lighting only. This approach cuts down on equipment size and weight, saves on infrastructural and transport costs, and increases the chance that local people's participation in the project will be effective and sustainable. Because the step by step approach begins small, it also means that misuse of the system has a relatively small and relatively easily addressed set of consequences. It is much easier to teach people who are not familiar with the basic concepts behind the electrification technology how to use, maintain, and trouble-shoot simple, small systems than large, complex ones. Once the basic conceptual framework is familiar and well understood by local people it is then considerably easier to expand the system to support local industry or other applications. Thus the basic village electrification system that we begin with is a small, embedded power generation unit just for minimal lighting purposes, utilising and converting the locally available, renewable energy resources. In this paper we describe one such system, which produced electric power with a pico hydro power plant[1]. The pico hydro power plant we installed in the village of Kholsi in December 2006 generates 1.1 kW at a maximal water flow of 83L/s, with a negative head and a conical draft tube of 2.7m length. Working in the pico range means that the chosen lighting technology's energy demand must be small. Therefore, the ISIS/RIDS-Nepal project, in collaboration with the local Nepali company Pico Power Nepal (PPN), developed WLED (white light emitting diode) lamps, each lamp holding 12 diodes (Nichia NSPW510CSE), with the unit consuming just over 1 watt. These WLED lamps are almost unbreakable, and last > 50'000 hours (this is ~20 years of use, if used for 7 hours each day). Further, the entire pico hydro power plant infrastructure, including the power house and the water canals, are built with locally available materials such as stones and wood, provided by villagers as part of their voluntary contribution to the project. In addition to providing these materials, individuals from every household in the village contributed labor and skilled assistance to the building process and installation of the project components. At the completion of the project, villages were proud of their achievement and described a strong sense of ownership in the entire endeavor. This stood in stark contrast to a hydro scheme several villages to the north, that was conceived of, designed by and implemented by foreign aid workers. Few, if any local people were involved in a buy-in to the system that could have been achieved by contributing materials or labor of their own accord, nor, according to villagers in that region, were any local people trained on the maintenance of the system. It quickly fell into disrepair. In our project, buy-in, participation and local sense of ownership were prioritized and openly acknowledged by project participants. While these issues are not a guarantee for long-term sustainability, they are important steps in the direction of a new paradigm of development. Kholsi village has 67 homes and one school, and each house now has three WLED lamps, while schoolchildren in class read under an additional nine. Thus a total of 210 WLED lamps are powered via armoured underground copper cable by the generator. Householders' usage of the system for lights consumes a maximum of only 250 watts at any time. Realising this, we modified the system so that 850 watts or more can be diverted full-time by a specially developed ELC (electronic load controller) to a water heater. This heater heats water in a 500 liter plastic tank that is insulated with pine needles and nestles within a larger, 1'000 liter plastic tank.

[1] A pico hydro power plant is considered in this paper as a power generation system with < 5 kW power output.

Figure 4: Beside the generator, the turbine and roof, the Pico hydro power plant infrastructure is built without any cement, using only locally available materials such as stone and wood. that creates a strong ownership among the users.

Figure 5: Inside the power house of the pico hydro power plant. The 1.1 kW generator is seen, with the wooden water canal, which cleans and streamlines the water for the propeller turbine's intake.

Figure 6: With 210 WLED lamps running, another 850 watts are diverted to heat water for hot showers and cooking food.

Figure 7: With 615 Volt AC the power is underground transmitted to the village.

Figure 8: The WLED lamps are power by 225 AC in the village.

The warm/hot water generated by this system is used for showering, improving hygienic conditions. It can also be used to prepare meals, reducing firewood consumption even more than already reduced by usage of the efficient smokeless metal stoves installed in each family home, as part of the Family of 4 HCD approach.

Figure 9: AC WLED lamp with 12 NSWP510CS diodes, consuming a total of 1.1 watt. These WLEDs have a life expectancy of > 50'000 hours, which is more than 20 years for an average household's use.

Figure 10: Humli family in their main room with two WLED lamps. The lamps provide enough lighting for people to see one another and to do daily indoor tasks such as cooking, cleaning, socialising and school homework.

Figure 10: WLED lamps for minimal but locally appropriate long lasting light services. Alongside is also an efficient smokeless metal stove, designed for the particular local cooking and heating needs, installed.

Figure 11: Education is known to be a powerful tool in development, and benefits powerfully from the introduction of indoor lighting. Evening non-formal-education classes can now be held.

Figure 12: Proud and participatory owner of a pico hydro power plant. The community has chosen one of their own people to be specially trained to operate and maintain the pico hydro power plant.

5. Conclusion

Our experience in this field shows that in the context of remote and impoverished mountain villages in Nepal, small power generation systems are on a locally comprehensible, locally sustainable scale, and are therefore highly suitable for such communities, at least as a first step in the electrification process. It is crucial to include all the stakeholders in projects such as ours from the initial concept/design stage through to its official hand-over to the local end-users. We also believe that the commitment of the project partners beyond the implementation phase is compulsory, to follow-up and continue to support end-users how to use and maintain their new power system. This may demand a commitment to local, on-the-ground staff who remain in the community for some defined period beyond the implementation phase. Our experience has proven that though this demand is rarely heeded by development efforts like ours that are occurring in other settings around the globe, it is certainly worth the investment.

Unless a paradigm shift toward retooling development efforts in the direction of many small scale, bottom-up, grassroots-involved, holistic community development projects, we feel that there is little hope for reaching the noble but heretofore unobtainable MDGs. While there is no silver bullet solution to the challenges of international development, the "Family of 4" concept, integrated in a long-term HCD approach, has already shown to be a giant step forward into the right direction for a new "millennium of development", at least in the context of our project areas. Once this seed of holistic community development is re-planted in the minds of international development professionals, and its results are appreciated in the minds of the beneficiaries of these efforts, the concept will continue to grow and take shape in the various sectors in which development is proceeding. With time, both sides of the development divide – those offering assistance and those receiving it – will see and experience the practical and mutually beneficial, synergetic benefits that an HCD approach is able to bring forth. We believe that this process will not occur in a year or two, but will likely unfold over the course of two generations of intensive living and working with the people we are helping escape the vicious circle of poverty and hopelessness. This is the cost of dignified and respectful development that we advocate.

6. ACKNOWLEDGMENTS

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Authors' Curriculum Vitae

ZAHND Alex has a mechanical engineering degree from Switzerland, and a Masters in Renewable Energy from Murdoch Australia. His industrial experience ranges from development projects in extrusion technology for the food and plastic industry, to pharmaceutical production plants. He lived and worked from 1996 - 2000 in one of the remotest and poorest mountain communities in the Nepal Himalayas, in Jumla, as director of a holistic community development (HCD) project. Since 2001 he has been a member of expatriate staff of Kathmandu University, involved in teaching Renewable Energy courses as well as in applied research of renewable energy technologies. Since 2002 he combined his extensive field experience and applied academic research projects by developing and leading a long-term HCD project and a High Altitude Research Station (HARS), in the very remote and impoverished north western district of Humla through the established NGO RIDS-Nepal (www.rids-nepal.org). The HCD projects are designed, implemented and followed-up in close partnership with the local village communities and local manufacturing companies. He is currently also working on his PhD in rural village electrification systems and a new HCD approach for Himalayan villages.

McKay, Kimber is a cultural anthropologist who specializes in demography, health and human behavioral ecology. Dr. McKay has worked both full time and as a consulting anthropologist designing studies of health and treatment of illness in remote areas of Nepal and Uganda. She has lived and worked in Nepal frequently from 1994 to the present, and assisted in the design of locally appropriate development schemes aimed at improving health conditions, particularly in the use of sustainable energy technologies and in public health-related interventions such as latrine design, improved/smokeless cook stoves, lighting schemes, community based health training, and drama programmes with specific health-related messages.