Taksindu Monastery Solar Electric Lighting System

A REDI INITIATIVE

Taksindu is a Sherpa Buddhist monastery which sits on the cusp of the divide between Solu and Khumbu, Nepal. It is a residential school for 60 monks and nuns and 20 lay people, and is the primary religious institution for the surrounding community. The monastery burns over 1,600 litres of kerosene per year for lighting, at a cost of over $1,400. This presents serious public health issues which this project was designed to address. Over the life of the proposed solar electrical system, the monastery can avoid burning 48,500 liters of kerosene, and save $43,000, which is almost exactly the cost of system installation.

Because of the out-migration of Sherpas of means, the highland communities are slowly losing their social and financial base. It is the belief of the director of this monastery that electric lighting will reinstill public interest in the institution as a viable and healthy campus for learning and cultural survival.

REDI

RENEWABLE ENERGY DEVELOPMENT INTERNATIONAL

Project Objectives

Provide a healthy and high-quality alternative to the use of kerosene for lighting, thereby eliminating the adverse health and environmental impacts of burning hydrocarbons in closed rooms.

Project Features

-200 lights
-recharging facilities for radio and flashlight cells (batteries supplied)
-stand-alone powerhouse
-buried cable
-fire extinguishers
-fail-safe design
-installed to U.S. codes
-maintainence fund

A closed-loop system prevents unintentional mis-use of the resource by first-time users of electricity. Fail-safe features are designed-in.

Project Benefits

Removal of kerosene from the environment has immediate impact on public health realities. Electric lighting inherently improves literacy, and also allows ceremonies to be performed more smoothly. Cooking tends to improve, as does social interaction. Cash previously spent on kerosene can be saved.

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GRANT REQUEST

BACKGROUND:

Taksindu is a Sherpa Buddhist monastery in the heart of Solu Khumbu, Nepal. It is a full-time residential monastery of 80 people.

While most of the monasteries in the region have been electrified, Taksindu has not, even though it is a primary educational and religious institution. Its' lack of a large enough water supply nearby precludes hydro-power generation, which could provide enough power for cooking and heating. Luckily, the monastery has access to plentiful fuelwood, but if Taksindu is ever to benefit from electric lighting, the only feasible solution is to install a solar photovoltaic system at the monastery.

REDI has designed and installed all of the solar electric lighting systems extant in the Junbesi Valley monasteries (Chiwong, Tumbuk, Phungmoche, and Thupten Choling), as well as provided voltage stabilizers to those other monasteries that are connected to small local hydro grids (Serlo and Phungmoche), as this compensates for transmission line losses by boosting the incoming voltage back up to 220volts. REDI began these projects in the fall of 1993, and has installed a total of 173 lights, which serve about 400 people on a daily basis, as well as serving the wider community during festivals and formal ceremonies at the monasteries. These systems are inspected once each year, and we are pleased that all are still operating as per specifications. Routine maintainence is performed by trained monks at each monastery.

OBJECTIVES:

The first of several objectives is to improve living standards at the monastery so that young people in the area will be encouraged to enter the institution and be inclined to stay there, due to the expanded facilities that electricity provides. The Sherpa areas are suffering from the out-migration of their best and brightest, and this is a frequent topic of conversation amongst the Sherpa themselves. It is widely expected that improvement of the area's primary religious and educational institutions will facilitate cultural survival. Electricity will enable the 80 full-time residents of Taksindu to read longer and better in proper light, and to see their texts clearly during ceremonies. The collective space during gatherings can be lit long into the night. Electric lighting will promote social cohesion, and be a source of pride for the monks and the local community. The cooks will also be better able to see the food they prepare.

But most importantly, the monastery will no longer need to buy and porter kerosene, or to buy and maintain lamps. Eyestrain, ulcers, and respiratory problems are all the result of burning kerosene for lighting. The total expenditure of time and money for the use of kerosene for lighting is surprisingly high (see appendix).

REQUEST:

REDI is seeking funding for the Taksindu electrification from a wide assortement of participants who wish to join our long-standing involvement and committment in the region. Some of you may also be acquainted with Taksindu's Lama, Kenpo Ngawang Ragba (Rinji Sherpa).

EQUIPMENT & BUDGET:

This is a lighting-only system, and is not intended to provide energy for heating or cooking. That amount of power would require a huge array of modules, and would present significant safety issues.

1) array: Twenty 75watt modules for 1500watts@24volts/60amps	$10,000
2) batteries: Eighteen 100amphr deep cycle @24 volt/900Ahrs	3,250
3) inverter: Trace DR4524E (4.5kw ac supply)	1,750
4) charge controller: Solarboost 50 MPPT	480
5) lights: 500bulbs @ $3 each (Chinese domestic)	1,500
6) battery recharger and cells for radios and flashlights	350
7) wire, fixtures, & labor for installation	6,000
8) safety equipment: fire extinguishers, lightening protection, etc.	500
9 shipping, porterage, transport	3,000
10) REDI expenses (all inclusive, see text	9,000
11) maintainence fund (see text)	3,000
12) tracker (including shippment to Nepal)	3,500
13) contingencies (8.6% of budget)	4,000
TOTAL BUDGET	$46,330

All costs for equipment and supplies are standard retail prices in Kathmandu. See appendix for technical calculations used to derive the system size.

DESCRIPTION OF SYSTEM:

This is a 200 light system. The lights are maximum 15watt compact florescent type, for a total of 3000watts maximum load. Recent development of the "energy saver" compact florescent bulb for domestic lighting has made it possible to provide a high volume of luminance at 25% of the power comsumption of standard incandescent bulbs. The CF bulb combined with solar electrical systems makes it possible to provide a high quality/low cost/low maintainence package.

An inverter converts the DC battery power to AC power for distribution, and is sized to 150% of the nominal load so that the system can be easily enlarged at a later time by adding modules and batteries.

The system includes a battery recharging station for flashlight and radio cells. A stock of rechargeable batteries will be supplied. At present, exhausted batteries are thrown on the ground. Recharging facilities at the monastery will keep this toxic litter out of the environment, and will allow the monastery to collectively save the money it has been spending on fresh batteries.

The only major item to be imported will be the tracker. A tracker for the modules is necessary because of Taksindu's weather realities, it being situated on the cloudy ridge between Solu and Khumbu. There is enough solar insolation at the site, however, during much of the year moisture accumulates in the form of clouds at the margins of the ridges surrounding Taksindu. The tracker will automatically move the modules in these difficult conditions, to their maximun input point vis-a-vis the sun.

All of the electrical cables between buildings will be buried in the ground in conduit, so as not to be a visual distraction or a safety issue.

Special features are included to prevent the system from being inadvertently misused: 1) no recepticals are provided for plugging-in appliances, TVs, etc. , since new users of electricity don't distinguish between DC and AC power, or different voltages. The strategy is to prevent anyone plugging-in an incompatable device which could ruin the systems' electronics. 2) locked junction boxes containing a 100watt circuit breaker are installed in every room where the wiring enters. This prevents any individual from splicing-in a free-lance recepticle in their room and pulling an inequitable amount power from the system. If this should occur, the breaker will trip, and the individual must call the monastery's Lama to reset the breaker, as the box is locked. The Lama will see if there are improprieties. A further advantage to the breaker boxes is that if one light malfunctions and trips the nearest breaker, that breaker is isolated to a maximun of three lights, and will not shut off the entire building. Troubleshooting system problems is thereby simplified as well. 3) screw-base fixtures with integral pull-chain switches are used for the majority of the lights. This is done for two reasons: a) fixtures with integral switches obviate the need to run 25% more wire for mounting switches on walls, making installation cheaper and easier b) while standard Nepali/Indian lightbulbs are bayonet-base, screw-base fixtures are installed to prevent the unsophisticated new users from installing standard incandescent bulbs from the bazaar. This would consume 4 times the power for the same luminance as the CF bulbs, overtaxing the entire system. This can be permanently avoided by simply using Chinese domestic market screw-base CF bulbs, 500 of which will be provided for this 200 light system. Trade linkages between the monastery and the Kathmandu supplier of these bulbs will be established, to insure future supply when necessary 4) the bulbs installed within reach in public spaces will be in tamper-proof fixtures, and the switches will be in locking boxes to prevent "curiosity damage" by visitors. All other public space lighting, such as overheads, will be tasteful and appropriet.

All other main components (modules, controls, battery bank) are Western made but are available in Kathmandu. The PV modules which produce the electricity are by Siemens, and are guaranteed for 20 years. The batteries are deep-cycle storage type by Trojan of the U.S., and are specifically made for installations of this nature. The batteries have the potential to last 10 years.

The primary components will be installed to U.S. code standards, i.e., rated breakers, grounded line, shielded cable, lightening protection, etc., and fire extinguishers will be installed at the power control center and inside the major buildings. For safety and maintainence reasons, the control center, batteries, and solar array will be installed in a dedicated powerhouse building which will be constructed on-site at an unobtrusive location at the South end of the compound.

MAINTAINENCE:

The electronic controls for PV systems are very sophisticated and reliable, and automatically control a variety of variables so that the systems are virtually maintainence free. The only maintainence will be periodic checking of the battery water level, and many of the Taksindu monks are capable. In the event of a serious problem, the staff of the Saleri/Chialsa hydro (20km from Taksindu) are very capable, and there are reasonable air links to Kathmandu for parts and professional repairs when necessary.

Long-term issues such as battery replacement after some years, is accomplished by establishing a maintainence fund as a budget item. This fund of $3,000 is placed in the local bank at project completion, and will accrue interest in perpituity. When the battery bank needs replacement, or any other maintainence issues arise, dedicated funding is in place which will be taken only from the interest on the original principal. Only the monastery's officials will have access, and three signatories will be required to withdraw funds from the account.

TIMING:

The installation work at Taksindu will begin within six months of the receipt of funding to undertake the project, and will require six to ten weeks. Many months of prep time are also required to design and assemble the "kit" required to be transported to the site in order to build this system in its remote location.

PARTICIPANTS:

REDI attempts to facilitate local participation wherever possible, by using local labor and suppliers. Critical system components (modules, controls, battery bank) will be purchased from Lotus Energy, a supplier in Kathmandu. The bulk of the installation supplies will be purchased on the open market in Kathmandu. We will transport the equipment and tools by truck to Jiri, and then porter them 5 days up to Taksindu. This will inject 500 to 700 man/days of wages into the local economy, rather than these transport fees going to a non-local helicopter transport company.

REDI has a standing agreement with Mr. Puri Lama, general manager of the Saleri/Chialsa Electric Company (SCECO), to contract the services of his electricians. They will lay the wiring for the lights, and the resident monks and nuns of Taksindu will decide where they wish the lights to be placed. REDI is the contractor and job foreman, and will direct the local electricians, and instruct the monks in renewable energy, as the job proceeds. REDI always trains several monks in system awareness and to perform basic maintainence tasks. REDI then installs all critical components, and brings the system on-line.

Linkages will be established between the monastery and the service technicians of SCECO, the local bank for maintainence fund, the Kathmandu bulb supplier, and Lotus Energy in Kathmandu for the servicing of the original warranties on the equipment.

The SCECO technician, Kul Narayan Shrestha, proved to be a superb leader and electrician on REDI's last installation at Chiwong. Kul knows solar electrical systems, and has the permission of SCECO to be on-call for any servicing requirements for REDI's projects in the area.

OTHER REDI PROJECTS:

There are a number of magazine articles describing our work, which are available on REDI's website: www.redi-org.com. These include:

The solar electrification of four monasteries in Solu, Nepal, and the design and installation of a hydronic circulating heating system in the Namche Dental Clinic.

REDI is also developing a comprehensive program to introduce a village-scale public utilities program to the remote regions of Nepal, and then internationally.

REDI's ORGANIZATION:

REDI is a 501(c)(3) non-profit charitible organization. Our Board of Directors includes Mr. MC Mehta, the crusading Indian environmental lawyer who recieved both the Goldman Environmental Prize as well as the Ramon Magsaysay Award in the late 1990s, and Mr. Howard Davis who is professor of Architecture at the University of Oregon, and is a member of the Center for Housing Innovation, the Faculty in Historic Preservation, the Center for Asian and Pacific Studies, the Society of Architectural Historians, the Vernacular Architecture Forum, and is the author of The Culture of Building, Oxford University Press, New York, 1999.

REDI's President, Dennis Ramsey, was a Unicef Project Officer in Nepal in the 1980s, and was a full-time resident of Kathmandu for 12 years, where he worked as a consultant to the printing industry, and in business. He is also the Vice-President of the Eugene/Kathmandu Sister City Committee which is affiliated with Sister Cities International.

REDI has a very limited operating budget, and we rely entirely on donations for both project costs and operating expenses. We use selective mailings to invite contributions for specific projects. All of our project funding has come from private individuals, with one governmental contribution, two non-profit charity contributions, and one contribution from a public utility.

REDI has included budget line item #10, which covers the following expenses which we will incur during the project period: round-trip airfare for one, salaries for staff, food and cooking facilities for REDI workers on-site, local fees as required, and basic living expenses for the project period.

BANKING INFO:

USBank, 800 Willamette St.
Federal Reserve Number:
Telephone:
Account: REDI #
EIN#:

THESE DETAILS NOT AVAILABLE ON THE WEBSITE....

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APPENDIX: ELECTRICITY vs. KEROSENE

Each individual monk at Taksindu uses 80 Rupies (US$1.14) worth of kero per month for personal lighting, and the luminance of their wick lamps is quite low. Kerosene purchased in the mountains is nearly three times the cost compared to Kathmandu because it must be portered and retailed there.

By contrast, the cost of the electricity (Nepal Electric Authority rates) to operate one 15 watt compact florescent bulb per month is: (15w x 4 hours per day = 60watthrs/day x 30days = 1.8kw per month x 7 Rs. per kw unit =) 12.6 Rs. per month. This is a cost ratio of over 6:1 *in favor of electricity*, and it is a modern, clean technology.

For a monastery like Taksindu, where the electric light would be provided as a donation, this means that they can save 80Rs per month per person, as well as the amount they have been spending to operate their petromax lamps during ceremonies. The total saved by the monastery would be: 1) 60 people x 80Rs = 4800Rs. per month, plus 2) 10 formal ceremonies per month x 5 lamps per ceremony x 80Rs kero per each lamp= 4000Rs per month. The monastery will save a total of 8800Rs. per month, which amounts to 105,600Rs ($1,424) per year in kerosene costs. Projected over the nominal life of a maintained solar electrical system (30 years), the monastery would save about $43,000, and would have avoided the adverse health and environmental impacts of burning 48,500 liters of kersosene in that time.

NATIONAL STATISTICS:

The total volume of kerosene consumed by all sectors combined in Nepal per year, is about 380 million litres (1999), an increase of 38% since 1995. During this same 5 year period, fuelwood use increased by 6.5%, and electricity use by 26%. In 1999 alone, kerosene use increased by 12% over all other forms of energy consumed.

The total volume of kerosene consumed by the domestic sector alone for 1998/99, was 226.3 thousand Tons (TOE), which is equivalent to 164,203,280 litres per year (one litre of kero weighs 800grams). At a present cost of 22Rs. ($0.30) per litre in Kathmandu, this equals $48.8 million per year that Nepali households spend on kerosene. This figure does not account for the significant increase in price as kerosene is distributed throughout the remote rural areas, where the cost of a litre can be as high as 70Rs.

In 1999 there were approximately 4,380,000 Nepali households. Therefore the average price paid per household per year for kerosene is $115 at nominal Kathmandu rates. While this may seem an outlandish figure, it must be noted that Taksindu monastery spends over 12 times this amount per annum. Source: Stastical Pocketbook, HMG, 2000, p. 89. It should also be mentioned that kerosene costs are increasing dramatically.

The figures indicate that households and/or individual users would consume electricity for lighting if it were available, but that energy use in the household still favors kerosene due to its availability.

Comparing the cost/benefits of electricity vs. kerosene in terms of pure energy potential is not easy because of the difficulty calculating comparable BTU's per unit, and there are too many variables. But the benefits of electricity appear obvious. Lighting with kerosene has many drawbacks because it is a burning hydrocarbon. It burns very inefficiently, and does not produce significant luminance unless burned in a costly petromax lamp. Even then, it produces a significant amount of smoke and noise. And kersosene also has to be carried with some effort to the point of use, and then stored.

Electricity has quite a few major benefits over kerosene in that it is cheaper, it is perpetually on-site and on-line, and it has no adverse health or environmental impact. Electric light also provides sufficient luminance so that individuals are able to study properly or work at night, and so has an immedeiate effect on education levels and overall productivity in the social and material realms.

TECHNICAL ANALYSIS:

Systems of this nature must be carefully designed so that the parts are properly sized in relation to one another. The biggest mistake usually made in designing systems, is oversizing the battery bank. The bank must be brought to full charge on a regular basis, and if it is too big for the array, it will have a dramatically shortned life.

The specific geographical setting vis-a-vis the sun is an important factor, as is the expected daily demand from the lights.

Input factors are usually calculated at a planetary average of 4 hours of full sun in order to estimate available power. These calculations are all made based on the nominal ratings of the equipment, and the real-world figures will vary somewhat.

1) The size of the monastery dictates that the system be 200 lights. Bulb size will average 15watts x 200 = 3000watts maximum possible load. Yet because all lights will never be used at one time, we can estimate that on a sustained daily basis, approximately 80 lights will be in use. A reasonable estimate would assume 4 hours of usage per night. 80 lights x 15watts = 1200watts x 4 hours = 4800watt/hours daily power consumption.

2) The sizing for the array of modules needed to deliver this amount of power is therefore at least 1200watts of modules, and given that input can also be averaged at 4 hours per day, this equals 4800watt/hours daily power input. Because the health of the battery bank, unpredictable weather conditions, and the variance of usage must all be considered, the sizing of the module array must be increased to 1500watts.

3) The size of the battery bank for energy storage must be carefully balanced between yearly input and yearly useage. Both average daily input and average daily useage in this case are 4.8kw., and while this might seem to indicate that the battery bank will simply cycle this precise amount of power every day, this is a nominal assumption and does not imply statistical stability over time. Both the season-to-season lighting usage pattern, as well as the season-to-season sunlight availability must be considered.

During approximately 10 days each month, the monastery holds ceremonies, and will use approximately 40% more power during this 30% of total time of use. And during the winter months when weather conditions are less friendly for power production, the school is in recess and the power demand will drop by approximately 60%.

All things considered, the health of the battery bank is the most important consideration, and so it should be slightly under-sized in relation to the module array so that it can easily be expected to cycle near the top of its range. It is only under such circumstances that a battery bank can approach a 15 year lifespan, and this is of primary importance because of the remote location of the monastery, the lack of technical sophistication of the users, and the expense of failure, so we must mitigate this important maintainence and life-of-system issue.

In the analysis above, daily useage and daily power input are nominally equivalent. However a 20% loss of stored power must be calculated to account for internal resistance losses, so the battery bank must first be sized 20% larger than the modules' daily input. The modules will produce

250 Amphours per day, plus 20% = 300Ahrs. Next, we must provide 3 full days of storage of this amount of power for poor weather and vageries of useage. 300 x 3 = 900Amphours battery bank.

These are the issues and calculations that must be taken into account when designing a solar electric system of this nature.

Please see REDI's various magazine articles describing similar projects for an expanded treatment of these issues.