Ladakh - Solar PV on top of the world

In September 2001 the Indian government approved a Rs 3.4 billion (US$ 70 million) programme to solar electrify an entire region of northern India over the coming 5 years. A proposed 24,000 Solar Home Systems (SHS), 12,000 Solar Lanterns and more than 2 MW of solar PV power plants are to be installed in the remote mountain region of Ladakh, on the Indo-Tibetan border.
The summer of 2002 saw the implementation of the first phase of this huge programme, with the installation of 10,000 SHS and the distribution of 6,000 Solar Lanterns.
Jos van den Akker and **Jigmet Takpa** report on this challenging and in many ways unique programme, which will make Ladakh one of the highest solar PV per capita regions of the world.

Buddhist monk at Stongday gompa, Zanskar: the proud new owner of a solar home lighting system.

A high-altitude cold desert

Ladakh, the "Land of many passes", is situated between two of the world's mightiest mountain ranges, the Himalaya and the Karakoram, at altitudes between 2,500 m and 7,000 m above sea-level. It borders Pakistan, Tibet and the troubled Kashmir Valley and consists of India's 2 northern-most districts, Leh and Kargil.
Ladakh is the most sparsely inhabited part of India with a population density of just 1.7 per square kilometre. It has a mixed population of Buddhist and Muslim subsistence farmers and nomadic herdsmen, the Buddhists having strong historical ties with Tibet. Farming depends entirely on irrigation from mountain melt-water, which is directed through an intricate network of channels to the terraced fields.
In the days of the great trans-Himalayan trade caravans the capital of Ladakh, Leh, was a nodal point and resting place for traders to recover from the extremely harsh conditions on the mountain trails.

The high mountains all around Ladakh form a natural barrier for the rain-bearing Indian monsoon clouds, and Ladakh receives less than 100 mm of rain per year. It is known as a high-altitude cold desert, with temperatures dropping to as low as minus 40 degrees Celsius in winter.

The estimated 170,000 Ladakhi people are living in very remote villages and hamlets, most of them with no motorable access road. Donkeys, ponies and yaks are used to carry heavy loads to the villages, or people themselves carry goods on their own back, sometimes several days walking.
Many villages get completely cut off from the outside world for more than 5 months per year due to heavy snowfall on the high passes that give access to them.

Superb for Solar
Ladakh is not connected to India's national grid. The extremely rugged terrain makes it physically impossible to electrify all the remote villages, apart from the prohibitive cost. The main towns have a Diesel Generator (DG) set or mini/micro-hydro scheme, or both.
Running and maintaining the DG sets is extremely expensive and they normally supply only 3-4 hours in the evening. Getting the diesel to these remote places is a logistic nightmare and there are frequent breakdowns which often means the village is thrown into darkness for sometimes long periods of time until a technician can come to repair it. The problem with the hydro installations is that due to the extremely low temperatures in winter, most rivers and streams completely freeze and these hydro-stations have to be shut down.


Ladakh – made for solar!

These same extreme climatic conditions make Ladakh ideally suited for solar PV applications. Average day-time ambient temperatures even in the midst of summer rarely exceed 27°C, which means solar PV modules are at their most efficient in producing electricity from the sun. In wintertime the modules are even giving more output than their rated STC (Standard Test Conditions) specifications due to ambient temperatures well below zero which increases the modules' efficiency.

18,000 Villages
India has implemented some of the largest solar PV programmes in the world, driven by government subsidies, tax and other financial incentives. Significant progress has been made over the past 20 years in the deployment of small Solar Home Systems (SHS) and solar lanterns, as well as street lights, water pumping systems and stand-alone PV power plants, with an overall estimated installed capacity of 60 MW. Worldwide this places India in fourth position behind such countries as Japan, the US and Germany in terms of installed PV capacity. [MNES, 2002].

There are about 80,000 villages in the country which are still to be electrified and hundreds of thousands of others which get only irregular service on the best of days. Of these 80,000 there are an estimated 18,000 villages in remote and difficult to access areas which cannot be electrified by conventional grid extension. Most of these villages are in hilly areas, forests, deserts and on islands.

On 19 July 2001 the Ministry of Non-conventional Energy Sources (MNES) called a meeting for the complete solar electrification of Ladakh. At that meeting, the Ladakh Renewable Energy Development Agency (LREDA) and the Ladakh Autonomous Hill Development Council (LAHDC) submitted a Rs 3.4 billion (US$ 70 million) proposal to install solar installations in all households, government and religious institutions (i.e. schools, monasteries and mosques) of Ladakh.
In record time, on 3 September 2001, MNES and the Government of India Planning Commission sanctioned this proposal and the preparatory work could start.
But first the high mountain roads giving access to Ladakh had to open again, which would not be until the spring of 2002....

Working against the clock
On 4 June 2002 the first of a total of over 100 trucks loaded with SHS and Solar Lanterns left the manufacturing plant of one of India's largest solar PV producers, based in South India. Its final destination is Ladakh, a more than 3,000 km long journey across the full length of the country, which would take an estimated 2 weeks to complete.
However, the truck journey up to Ladakh is in many ways the easy part of the whole exercise of getting the solar systems to the end-users. Once the truck reaches Ladakh, it is immediately directed towards to the farthest motorable point, as close as possible to the more than 80 villages and hamlets where the SHS are eventually destined to be installed. These off-loading points can still be up to 3-4 days walking away from the actual installation sites. After off-loading the truck the PV modules, batteries, battery acid jerry-cans and accessories are all loaded onto local transport, i.e. donkeys, horses, yaks and people's backs.


Lingshed village: 3 days walking from the nearest road

The risks involved in this last leg of the journey are substantial and during the project 3 donkeys fell into fast-flowing rivers with their loads and perished.
An additional risk is leakage of acid from the jerry-cans, which can get damaged during the long journey and pose a risk to both people and animals involved in transportation.
Ladakh is connected by only 2 roads to the outside world. One via Kashmir valley and Kargil, following the Line of Control (LoC) with Pakistan. The other, eastern route leads via Manali in Himachal Pradesh. Both routes are open for only about 5-6 months per year due to heavy snowfall in winter on the over 5,000 meter high passes.
Under "normal" circumstances these roads stay open until end of October, but with global climate change upon us, also in Ladakh the weather patterns are changing and are becoming unpredictable.

One thing was for sure, all systems had to reach Ladakh before these access roads would close. Furthermore, all SHS had to be installed and all solar lanterns distributed before the winter cold would make that impossible. The official deadline given by the government was 30 September, leaving barely 4 months to complete the entire programme. A race against the clock had started....

Fee-for-service
Most of the estimated 5,000 solar HLS and 2,000 solar lanterns which had been in use in Ladakh up until the beginning of this year were provided to the end-users free-of-cost and seen as a development tool to provide basic electrical service to people who will have no hope of ever getting connected to the national grid.

This time however, the SHS were not given to the end-users for free and it looks like some valuable lessons from past mistakes were learned. Giving away SHS and Solar Lanterns free of cost means people don't put any value in it, and the systems don't get maintained properly. By charging a nominal fee, it is expected this attitude will change.


FillFilling the battery with acid: handle with care...

Not only do the end-users pay Rs 1000 (US$ 20) initial installation charges per SHS, they also have to pay Rs 60/month (US$ 1.25/month) towards maintenance and battery replacement (after an estimated 5 years). Each end-user has to sign an agreement with the local government representatives (Panchayat) to this effect. The monthly fees are collected by the so-called Village Level Workers (VLW), and kept in a revolving fund. This way the money stays in the community, being administered by the Panchayat. Refusal to pay the monthly fees can lead to removal of the SHS, directly enforced by the local government officials.
Effectively, the SHS are being *rented* to the end-users, for which they have to pay the monthly fee, much like city dwellers in Leh who have to pay for their monthly electricity bill.
This is the well-known "fee-for-service" concept, which is already successfully used in countries like Honduras, Morocco, Kiribati and South-Africa.

Another way in which this programme was different from the previous ones is that the same companies which installed the SHS have to maintain them as well for the first 5 years after installation. Because of the remoteness of the areas where the SHS have been deployed, maintenance service centres are being set up a block-level. Each block-level centre will be (wo)manned by at least one trained technician and will have a stock of spare parts.
More complicated repairs will be done at district-level only. At this level it will for instance be possible to repair individual cells of the batteries by replacing the plates. Also component-level repairs can be performed on the Printed Circuit Boards (PCBs) of the charge controllers and luminaires.

Pushing the donkey
Meanwhile the first trucks had reached Ladakh and off-loaded their precious load at the various drop-off points. From there the villagers come to collect the systems to transport them to their final destination.

Lingshed is one of the fortunate villages selected to receive the first batch of SHS. It can only be reached on foot, taking 3 days and crossing 3 nearly 5,000 meter high passes. A remote location even by Ladakhi standards.

Heavily loaded donkey caravan with solar systems, pushing up the 5000 m high Sengge La pass.

Lingshed village has a large Gompa (Buddhist monastery) as well as a Buddhist nunnery. On our way back from a field inspection visit we came across a caravan of donkeys, lead by young Chomos (Buddhist nuns). They were just about to reach the highest point on the route, the Sengge La pass, exactly 5,000 m above sea-level.
It was an incredible sight to see the donkeys and nuns, both heavily loaded with SHS on their backs, pushing their way slowly to the top of the pass. One young chomo was literally pushing a donkey up the last few meters to the top of the pass!
It was on this same route that a week before one donkey loaded with 2 solar batteries fell off a small bridge and drowned in the fast-flowing river.

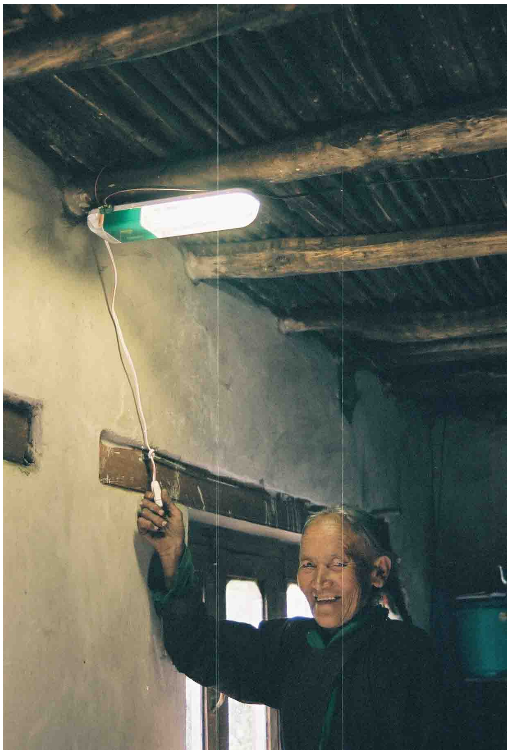
The installer's field offices in Leh and Kargil had not been sitting idle while the SHS were still en route to their final destinations. They had started to recruit installation technicians from among the local population, and ran a training programme to prepare them for their job as solar PV installation technicians. Over 50 technicians were trained for the job, so an average of 100 SHS per day could be installed during the 3 months of actual installation work in the field. Installing an SHS is not rocket-science, but it does require some, especially hands-on, training.
Apart from the standard technical training, technicians were explained the importance of educating the end-user in proper Operation & Maintenance (O&M) of the SHS.
Despite many years of familiarity with solar PV, it is surprising to see how end-users in many ways are still unaware of various aspects of operation and maintenance of SHS. E.g. batteries rarely get topped-up and if they do, people tend to put in a diluted acid solution which is available on the local market, instead of using distilled water.

Also many previously installed modules were found to be (partly) shaded and/or covered in dust and many charge controllers are being by-passed.
There is obviously still a lot of work to be done in the field of end-user awareness raising on O&M of the SHS.

Apart from the more practical lack of awareness among the rural Ladakhi population, there was also a remarkable complacency in case the SHS was not or only partly working. Because SHS and solar lanterns were distributed free of charge in the past, with no maintenance follow-up of any kind, people are not expecting anything to be done if a system doesn't work properly and look at such events in a rather fatalistic way. It had to be pointed out to them that this programme was different in that they were paying for a service provided to them and had the right to complain and get the system repaired. Also in this respect there is still a lot of room for improvement at the level of end-user awareness.

Freezing batteries

The SHS cost about US$ 300 each and consist of a 40 W_p PV module, a 75Ah deep cycle battery with oversized electrolyte reservoir, a solid state charge controller, and two 11 W fluorescent lamps. The system is sized such that both lights can be used for 3 hours every night in winter, with 2 days of autonomy.
The SHS had to incorporate some special features to cope with the extremely low winter temperatures prevalent all over Ladakh. Night-time winter temperatures of minus 30 Celsius are not unusual and one of the risks is freezing of the batteries. To reduce the chance of this happening the acid used in the batteries was of a relatively high specific gravity (1280 grams/litre). Also, the battery was placed inside a battery-box with polystyrene sheets all around it to give it some thermal insulation.



Let there be light! Happy Ladakhi customer

Also wires tend to get affected by the low temperatures and over time turn brittle and break. A special poly-ethylene sheathed cable was used which can withstand the low temperatures.

Lessons learned?

So far the programme has been well received, and the 10,000 SHS were installed in record time, before the winter snows closed the roads to Ladakh again. Most Ladakhis are quite familiar with solar PV and its benefits are much appreciated. Its reliability, independence of the grid and safety are all well-known. People call it "rangwang ot", or "any-time light". At the flick of a switch the light comes on. No more fiddling with cumbersome kerosene and wick lamps, producing smoke which is bad for health and can cause fires.

The biggest challenge for this project is yet to come though. As per their contract with LREDA, the same companies which have installed the SHS will be responsible for providing maintenance for the first 5 years after installation. Maintaining these systems over these 5 years (and beyond!) is going to be a major challenge in the remote and inaccessible regions of Ladakh.
Only if this difficult maintenance task can be accomplished we can speak of a successful and sustainable programme. A programme which was different from all the previous "free-for-all" give-away programmes which in the end didn't work, judging from the amount of un-serviceable SHS and solar lanterns one can find in many Ladakhi villages.

Time will tell whether the lessons we are now finally learning from our past mistakes and have incorporated in programmes such as this one in Ladakh, are actually going to work over a long-term period and lead to a sustainable use of solar PV in remote areas.

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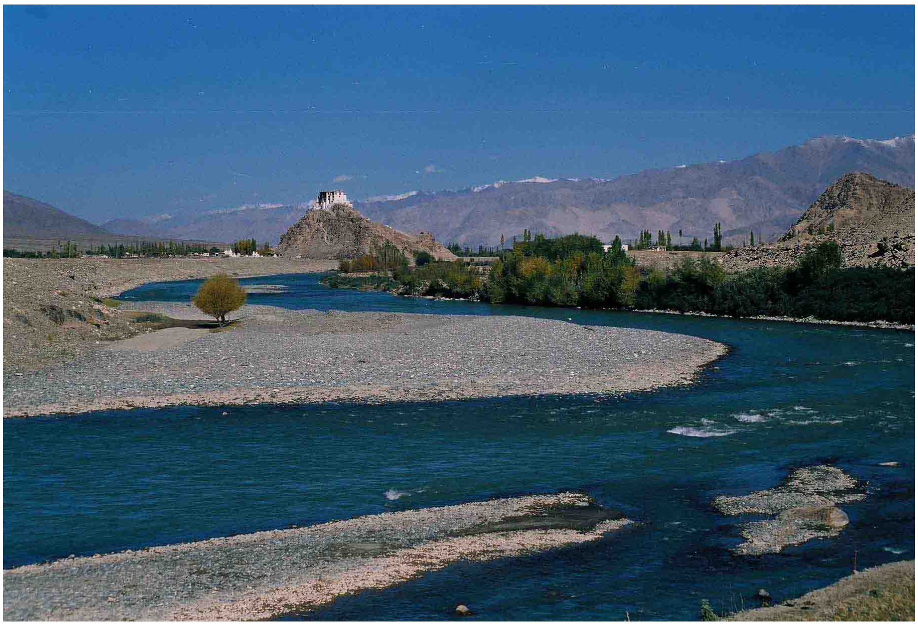
Stakna Gompa on the Indus river