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Greenpeace India Society
#60, Wellington Street, Richmond Town,
Bengaluru 560025, India.
T: +91 80 41154861 F: +91 80 41154862
E: supporter.services.in@greenpeace.org
www.greenpeaceindia.org
facebook.com/greenpeaceindia

TAKING CHARGE

Case studies of decentralised renewable energy projects in India in 2010

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Author Grace Boyle and Avinash Krishnamurthy

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Contact arpana.udupa@greenpeace.org

Cover image Operator Konchok Stanzin cleans the panels of the 100 kWp stand-alone solar photovoltaic power plant at Tangtse, Durbuk block, Ladakh. Located 14,500 feet AMSL in the Himalaya, the plant supplies electricity to a clinic, a school and 347 houses in this remote location, for around five hours per day.

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Introduction
taking charge

Taking Charge is a selection of case studies of small-scale, decentralised renewable energy systems in India in 2010. Each has two parts: the main story, which captures some of the remarkable human and social elements that have shaped these pioneering projects, and a quick-glance section, which provides an easy reference for the more technical aspects.

The strength of these stories lies in their diversity. One is a diversity of the context in which they are based, including the geography of the place, and its social fabric. From semi-nomadic pastoral tribes in the Himalaya, to caste-based politics in the deserts of Rajasthan, to church-lead community action in the hills of Kerala, renewable energy is seen being applied to the problem of energy access in a variety of contexts.

Another is the diversity of solutions applied. Each of these renewable energy projects has worked because they are tailored to fit the local needs and conditions. In Bihar, a company is providing electricity to over 100,000 people using the only waste product in the villages: rice husk. In New Town Kolkata, a housing project with grid-interactive photovoltaic technology has been built, ready for the next wave of urban development. Bankers are travelling to the most remote areas of Karnataka to issue loans to farmers to purchase tiny hydro systems for their homes.

Perhaps most interesting is the diversity of energy governance that these stories demonstrate, and the economic models that they have developed. In Delhi, a hospital is saving up to sixty per cent on its water heating bills from an enterprising company that has set up shop on its roof. Across Karnataka, a company is turning profit by providing solar services to people who were previously considered unbankable. In Tamil Nadu, a Panchayat is investing in wind energy to provide better public services for its citizens. And near the Andhra Pradesh border in Karnataka, an NGO, in partnership with a community organisation of 40,000 member families, has built 5,500 biogas units across 339 villages and is monitoring their useage daily.

Image: Pico-hydro power in Karnataka.

Image: Women benefit from clean biogas stoves.

Observing the challenges that these people have faced, and how they have chosen to overcome them, is fascinating. Yet despite the diversity of these stories, the challenges faced in setting up decentralised renewable energy projects seem to fit into three broad categories:

1. Social ownership and local governance. Who will own, run and regulate it?

2. Accessing technology, knowledge, services and training. How will they know what to do?

3. Accessing finance, and achieving economic stability. How will everything be paid for?

These stories demonstrate a variety of answers, which should be studied.

The call for renewable energy is most often heard as part of a prescription to mitigate climate change, and certainly this logic is valid and imperative. Yet the people profiled here only mention environmental concern as a secondary incentive for renewable energy, if at all. These decentralised projects make sense from a development angle alone. In India, where an estimated forty per cent of the population do not have access to reliable energy services, they are particularly relevant. Again and again, we see links between the energy access that these projects provide, and development indicators such as access to basic resources and bottom-up economic growth.

The title of this book is in part a reference to the generation of electricity, though not all the stories in the book are of electricity and neither are the energy needs of the population confined to it. It is primarily a reference to the grit and determination of the people who have fought for and developed these projects. Determination that they will no longer wait for the most basic of energy services to be given to them, or that they will no longer draw their energy in a way that is harmful. They will take charge, and lead the way to a brighter, more equitable future.

In individual learning is collective knowledge, and India can and should learn from projects such as these as it moves towards a low-carbon future.

CASE STUDY I

Image: Shibu Joseph in front of the stream that powers the Pathanpara micro hydro system, Kerala. Shibu is the secretary of the committee that manages the electricity-generating system, and was its first customer. My world opened up, he remembers.

Micro-hydro power in Pathanpara village

Western Ghats, Kerala

Anil Kumar and Samuel Thomas dreamt of creating power “without doing any big-big thing,” says Anil. “Big nuclear, big dams… all these things that are harmful.” In 1991, the government proposed a nuclear power plant in their home district of Kannur, in northern Kerala. The plant was framed as a solution to the area’s acute power shortage, but the community fought the plans with fervour. As part of the movement, Anil and Samuel argued that power needs could be met through a combination of better management of transmission and distribution - plus a lot of decentralised renewable energy systems. The two engineers needed a project to prove their point, a David to their Goliath. They decided to build one in Pathanpara, a small, unelectrified village close to both their homes.

Pathanpara is a hamlet of three hundred and sixty families spread across a small valley of the rolling Western Ghats. It comes under the larger Naduvil Panchayat, and is part of Kannur district. This is hill country, where farmers grow areca nut, coconut, rubber and spices on their small landholdings and, in the 1990s, lit their evenings with candles or kerosene lamps. There was no grid electricity, but plenty of perennial and seasonal streams in this verdant jungle region: a vehement monsoon delivers up to five metres of rainfall annually. There was even a stream in Pathanpara’s borders that had the potential to support a micro-hydro system. Socially, the church was, and is, pivotal: the west coast is believed to have been a landing point for Thomas the Apostle in AD52, and around ninety-nine per cent of the population in Pathanpara are practising Christians. The cross atop the church is one of the few aerial signs of settlement, poking above the valley’s canopy of coconut trees.

The church could galvanise the community across social divisions, and by 1991 had already led Pathanpara in setting up its own private bus service. Founded by community donations, the bus is still the only service connecting the village to the conveniences of the bigger Alakode, where Anil and Samuel live.

“People here are prepared to improve their conditions,” says Benny Matthew, a teacher at Pathanpara’s primary school. “Literacy is high, and it gives people ambitions. And the priest encourages and guides the people.” The level of initiative meant that Pathanpara was not entirely without power: individuals had improvised their own tiny electricity systems in their backyards, and the teashops in the village’s main street ran black and white televisions off car batteries. “First I had a bullet dynamo, then a jeep engine, set up to run off the local streams,” Benny remembers. “Simple. I had eight tube lights running at one point.”

In a similar spirit, Anil and Samuel sought to fight the nuclear power plant by building an environmentally friendly power solution that could serve the wider community. They realised the streams could be key to this, and spent months travelling the country to study small and mini hydro projects and talk to people about their experiences. In 1996, Anil even crossed the border to study a micro-hydro project in Nepal. In 1997, they had the sense to approach Pathanpara’s parish priest, Father Mathew Asaparambil. They explained to him their idea to create power in the village from one of the perennial streams. If they could convince the Father, they would gain the cooperation of the community. A proactive visionary, Father Asaparambil agreed and began to mobilise the people. “He was a good organiser,” remarks Benny.

The village sets to work

Thirty-six households donated Rs. 6000 each – over seventy per cent of the average monthly income in Pathanapara – and more donated their labour. Another 50,000 rupees were taken on loan from the Thalaserry Social Service Society, a local organisation. The forest department was persuaded to donate the same amount, giving the project capital of around Rs. 300,000 to set up with. Two pieces of land were donated for the project: one for the reservoir, and one for the powerhouse.

Though qualified engineers, neither Anil nor Samuel had built such a system before, and spent many hours figuring out the best specifications to turn the chosen stream into a reliable power source. Electromechanical equipment was ordered from around the country, and the turbine was cast in phosphoric bronze in a mould brought from Nepal. Anil was better at the technical side of things, while Samuel

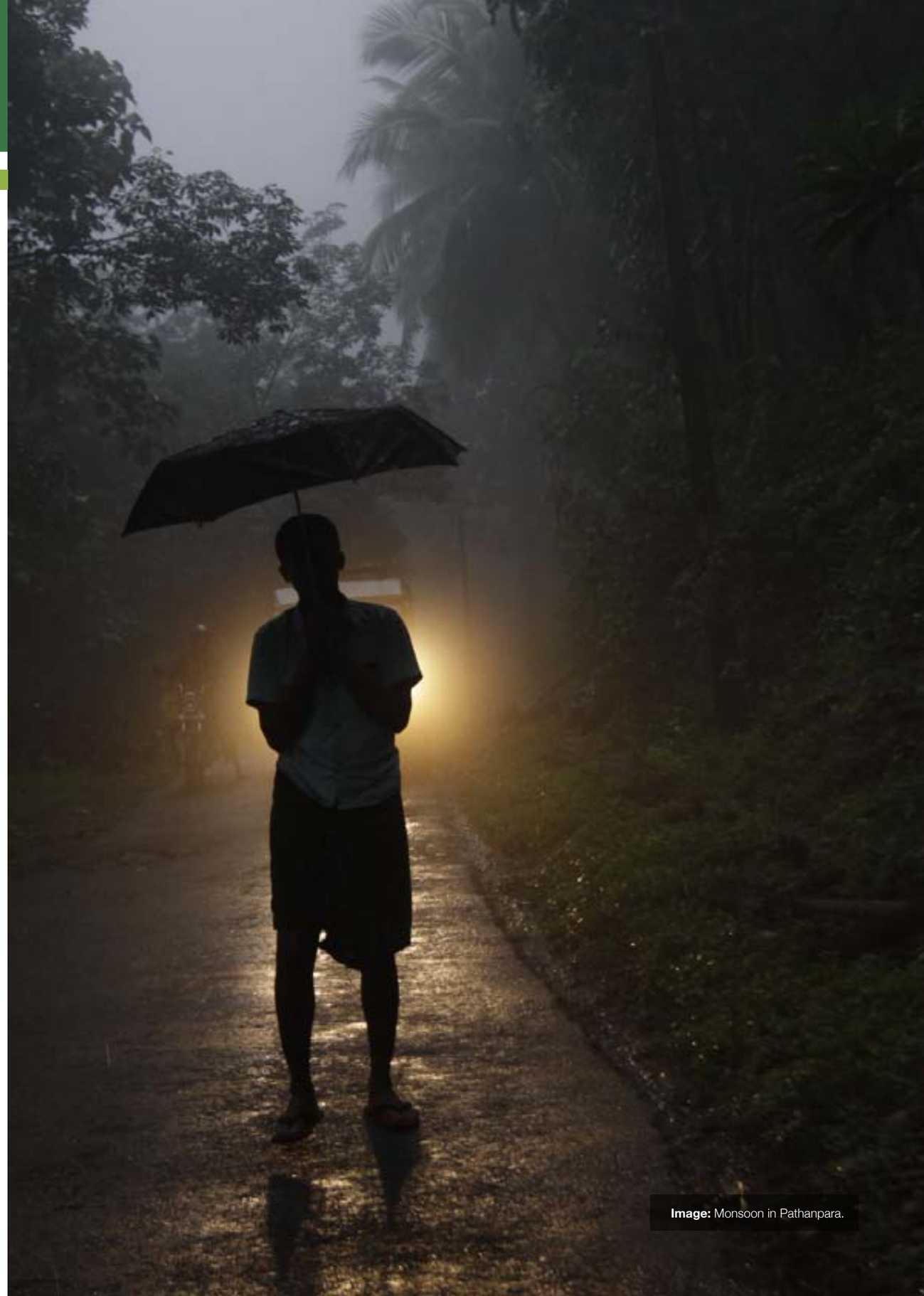


Image: Monsoon in Pathanpara.

Image: Anil Kumar, right, and a Pathanpara resident in front of the reservoir pond built by the village.

Image: "It was a very exciting time." Samuel Thomas, one of the engineers of Pathanpara's micro-hydro system.

excelled at the governance and planning. "It was a very exciting time," remembers Samuel, pointing to grainy photos of the construction group.

By December 1997, the team had diverted part of the hill stream into a crude reservoir pond, and installed a six-inch-wide pipe to carry the water a vertical height of sixty metres down the hill slope to a powerhouse. By the time the water hit the turbine, it was travelling at twenty-two litres per second: enough to generate 5kW of power.

"We didn't take any payment," says Samuel. "But [the villagers] provided us food." He pauses. "Food and liquor." He grins. Through their work, the two engineers developed almost familial ties with the residents of Pathanpara. Thirteen years later, the powerhouse is still a place of frequent revelry. A casual site visit by Anil can quickly turn noisy, as one man after the other shows up in moustache and *lungi*[1], carrying containers of hot food or a bottle of home-brewed wine.

Let there be light

The lights flickered on in Pathanpara on Christmas Day, 1997. The thirty-six households that had contributed financially to the set-up received connections at no extra cost, as did the primary school and two church-supported art clubs. The church was also connected, but insisted that it would pay. A mini grid extended up to two kilometres from the powerhouse to each of the users. Others in the village saw the system working and soon joined, until the total number of households drawing electricity reached seventy-five. Additional households had to pay a 'connection fee' of Rs. 2,000, however.

A committee of seven villagers was elected to govern, own and manage Pathanpara's micro-hydro system on a three year term. Father Asaparambil was appointed president and a man named Shibu Joseph as Secretary.

Shibu, the system's first customer, remembers using the power to watch television for the first time. He was twenty-seven. "My world opened up," he says. "My children's lives are very different as a result of the TV." Shibu rarely leaves Pathanpara, and has never been outside of Kannur district. In contrast, many of the younger generation are now working in the Gulf or Europe: far-flung ambitions that he accredits, with an air of approval, to their exposure to television.

[1]A tube-shaped cloth worn around the waist, particularly in southern India.

"Schooling has also changed in Pathanpara since the television," he adds. "People's work was agriculture, and they studied until tenth standard, maximum. Now their aspirations have changed, and people take up higher studies."

As part of the committee, Shibu and the other members set the tariffs for the electricity (see fact box, pg 14), based on providing different bundles of services rather than a metered system. They decided their income should cover an operator's salary and maintenance costs, but allow only a small emergency fund to accrue beyond that. Customers were divided into nine groups, and each committee member assigned a section to collect fees from every month.

There were some hiccups, of course

With the sudden luxury of electricity, the people of Pathanpara eagerly began to buy electrical appliances and plug them in to the new sockets that had appeared on their walls. Unlike a national electricity grid, which is treated as a limitless battery, the stand-alone micro hydro system had a fixed maximum capacity of 5kW, and therefore couldn't support a heavy load of iron boxes. The committee fixed electricity meters to the five cables that ran out of the powerhouse to identify households that consumed above their ration. They disconnected six users, explaining to them that the system couldn't support such appliances. The users had to pay five hundred rupees to be reconnected. No household in Pathanpara has overburdened the system since. All regulation is now socially driven, strictly adhering to the code of conduct laid out by the committee.

There have been other examples of good governance. The committee first used their slowly accumulating funds to pay off the loan to the Thalaserry Social Service Society. Later, the committee secured the land on which the powerhouse stood from Shibu's uncle, who had previously donated it for the project. They also knew it was important to protect the source of their power for the future, so they partnered with Thalaserry again to safeguard the stream's flow. With Rs. 5 million invested by the civil society, the partners built check dams and gully plugs. They also planted bamboo clusters along the banks to increase the groundwater percolation, and secure the base flows into the stream.

These micro measures made some difference, but not enough: the macro trends of the hilly regions of Kerala are

Image: Raju Arumathamattal Devasiya, operator of the Pathanpara 5kW micro-hydro system, in his office in the hills. The board of lightbulbs behind him acts as a dummy load, absorbing any fluctuations in voltage.

against them. Stream flow is said to be reducing in the Western Ghats as a result of changing monsoon patterns and mono-cropping. When the system was first installed, even the lean summer flow ran at twenty-two litres per second through the turbine. Shortly after the installation, however, the lean flow ceased completely. The committee had to purchase a diesel generator set in 2004, which they use to plug the deficit in April and May of each year. Money from work such as this comes from the aforementioned emergency fund, which hovers around Rs. 60,000. The committee's monthly income is Rs. 1,000 higher than their average outgoings, and they've been quite successful in accessing other funds to renovate the system when needed (see fact box on pg 14 for details).

In 2002 the committee revamped the holding pool in the hills above the powerhouse. A small section of the hill stream now diverts into a three-metre-deep stone pool, cool and aquamarine blue and dotted with dragonflies. The purpose of the reservoir pool is to create a steady flow of water through the pipe to the powerhouse. "If you want you can swim in it!" says Anil. "Fresh clean water." Another friend from Pathanpara appears from the undergrowth, waving a container of hot home-cooked food.

Micro, pico or mini?

Pico-hydro < 5kW capacity
Micro-hydro 5-100kW
Mini-hydro 100kW to 1MW
Small hydro 1-10MW
(Large) hydro >10MW

The grid enters Pathanpara

Everything changed when the national electricity grid entered the village in 2002. It was a move voted for by the community, who also channelled decentralised state funds to pay for a third of the Rs. 450,000 cost. The grid electrified the nucleus of Pathanpara, though many houses further out remained unconnected. Excited by the idea of limitless electricity, thirty-five houses in the village centre disconnected from the micro-hydro system and, flourishing electric irons, paid Rs. 7,500 to connect to the main grid. Thirty-five others, most of whom were located outside of the centre, retained their local connection, and four or five houses took both the grid, and retained the micro-hydro service.

It wasn't long before the electricity grid began to disappoint, however. Far from being an inexhaustible supply, the state electricity was low voltage and unreliable, as national shortages led to frequent load shedding in this rural area.

In addition, Pathanpara's remote geography caused problems: broken transformers would take two or three days to be repaired, and falling trees sometimes severed the connection completely. Slowly, the houses that had disconnected from the micro-hydro began to ask to be reconnected, but the window of opportunity had narrowed. The committee refused to reconnect all those who had so hastily left their system. Operating on a policy of no-profit-no-loss, they saw little temptation in the prospect of more fees, and instead preferred to reward their faithful customers with a higher load. Shopkeeper Jojo Michael, 35, was one of around five users who managed to persuade the committee to reconnect him to the micro-hydro system.

"I switched from the micro-hydro because it doesn't work in the summer, and you can only use lights," he explains. He owns a small goods shop packed with so much stock he can barely stand at the opening, and a teashop across the street. The teashop has a television, where people come to watch news and sports. During the 2010 World Cup, Jojo took back his micro-hydro connection so his customers could watch the matches without disruption.

"I could be sure it would provide uninterrupted power," he says. "And that meant good business for me."

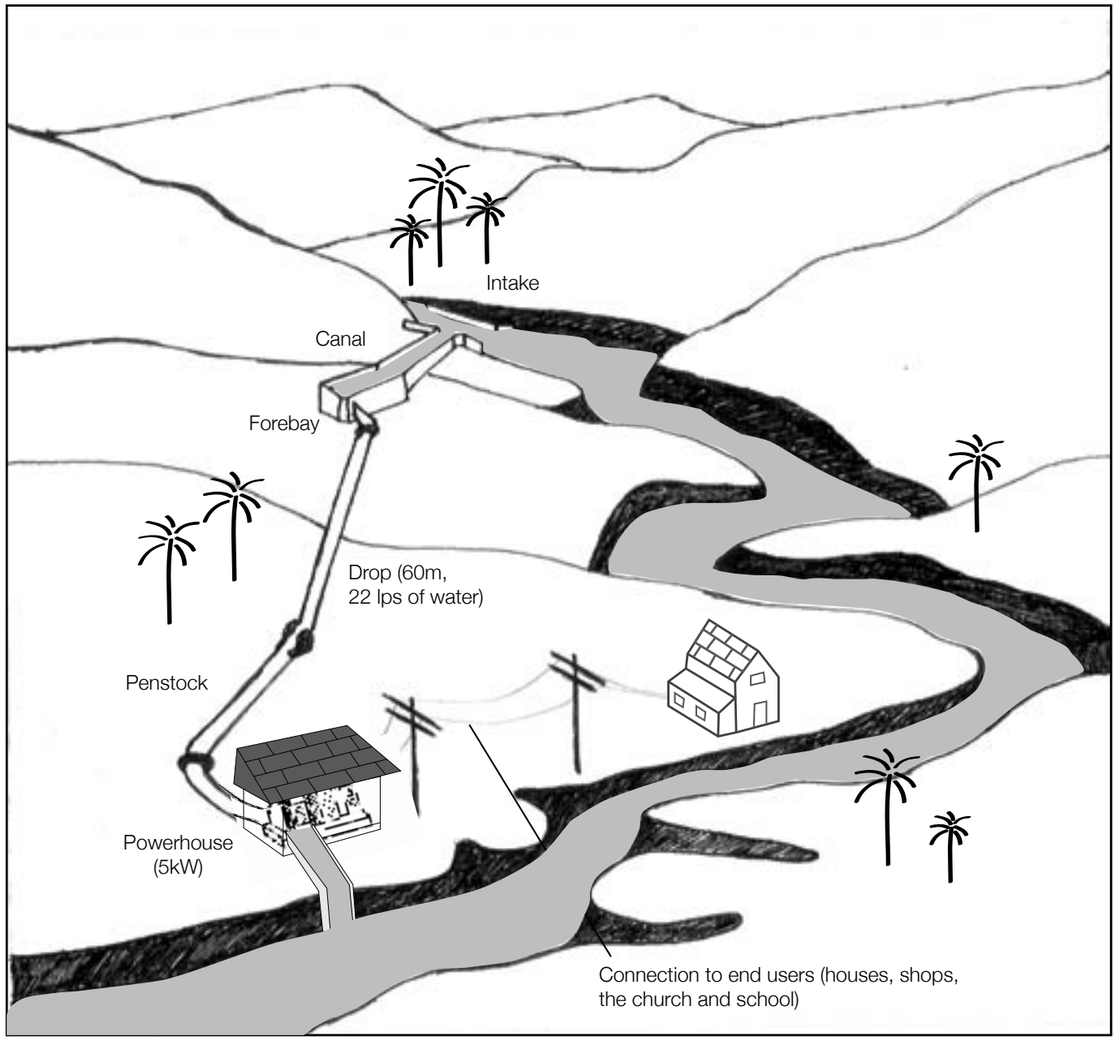
What now for this tiny electricity system?

Pathanpara's micro-hydro customers are loyal: after all, their electricity rates haven't changed in thirteen years. The system served well as a gesture against nuclear power, and withstood a clash with the nationwide electricity grid. Its committee is determined to continue, and to expand.

Anil and Samuel have calculated that the peak flow of the stream can generate 500kW for up to seven months of the year, and are suggesting that the community harness at least some of that to sell to the main grid, or to power seasonal industry. There are talks with Thalaserry Social Service Society to further protect the stream's flow. Whatever the next steps, they will be the product of the Pathanpara community, as was the original construction thirteen years ago. "The way we made it was not the proper technical way to work," confides Samuel, grinning at the memory. "But I felt that, in four years of studying engineering, we had learnt nothing. In three months, we learnt everything."

Image: A man pours tea in Jojo Michaels' shop. Jojo used the micro-hydro to power an uninterrupted screening of the 2010 football World Cup in his tea shop. That meant good business for me, he says.

Generating electricity through micro-hydro



Features to notice:

- Strong leadership of a community has been critical in setting up the project. In this case, leadership came from the church and priest.
- Initiative survived - and continued to be financially sustainable - despite the entry of the centralised electricity grid. Many potential customers were bypassed by the main grid.
- Wealth of social entrepreneurship exists, if lead and supported.
- The community is aware that their continuing power supply is related to the health of the local stream, which they have taken steps to protect.

Fact Box

Micro-hydro power in Pathanpara village

Where:	Pathanpara village, Naduvil Panchayat, Kannur district, Kerala.
What:	5kW micro-hydro system on perennial stream, lean flow 22lps, 60m head. Diesel back up.
When:	Built in 1997. Still functioning. Grid entered village in 2002. June-Dec: 24 hrs electricity/day, Jan-Mar: 5am -7.30am and 5pm -11pm, April-May: 6.30pm -10pm, plus approx. 3.5l diesel /day.
Users:	**Domestic:** 75 households at maximum of non-grid years. Currently 35, plus 4-5 connected to both micro-hydro system and main grid. **Other:** Previously primary school, two art clubs and a church. Now four shops.
Tariff:	Flat, not metered. Collected monthly, post-use. Connection fee of Rs. 2000 for domestic users joining at later stage Domestic bundle 1: Rs. 75/month for 10 CFLs, Domestic bundle 2: Rs. 100/month for 10 CFLs and TV, Other: Shops: Rs. 75/month for 2 CFLs, Art cub: Rs. 20/month for 2 CFLs and TV (subsidised rate), School: free connection and electricity.
Management:	Pathanpara Janakeeya Urja Samiti (Pathanpara People's Energy Committee). Registered charity consisting of seven elected members (three year term), a Secretary and the priest as President.
Finance Initial investment costs:	**Community donations:** 36 houses gave Rs. 6,000 each = Rs. 216,000 **Thalaserry Social Service Society loan:** Rs. 50,000 at 4% interest, repaid in monthly instalments of Rs. 650 (through revenue payments) **Forest department grant:** Rs. 50,000 (Received three years later and was used to make the pond a properly-engineered structure) **Purchase of pond land (over time, through revenue payments):** Rs. 200,000. Powerhouse land donated by community
Operating and maintenance costs:	Rs. 4,000/ month (Rs. 3,000 operator salary plus maintenance), 1998: New turbine, Rs. 20,000 (community donations), 2008: System service and upgrade, Rs. 75,000 (grant from Ministry of New and Renewable Energy).
Operating income:	Approx. Rs. 5,000/ month.
Contact:	Anil Kumar, Sigma Electronics. Email: anilsigma@gmail.com.

CASE STUDY II

Image: A street vendor sells vegetables lit by electric lamps in Karnataka. The lamps are charged by solar energy during the day.

Solar lighting systems, SELCO India

A social enterprise in Karnataka

Chanamma rolls beedis for a living. Her wages are directly dependent on how many of the leaf cigarettes she can make in a day. Her teenage son, Lokesh, is a daily wage labourer. With their combined income, Chanamma pays off a loan left by her late husband, runs the household and educates her only daughter, Taravati. For years, mother and daughter would use the weak light of kerosene lamps to work and study by. In this village, on the periphery of Puttur town in Karnataka, Chanamma's family, and those of her neighbours, have lived for generations without access to electricity.

In Chanama's children's generation, things are finally changing. In 2007, Lokesh heard from friends that his house could be lit with solar lights, and that a company called SELCO would help him do it. The word spread to his neighbours, some of whom decided that they too wanted the light. The group approached SELCO - which had a branch office in Puttur town - for help.

SELCO's great strength is that they assess the needs of every customer, and design a solution specifically for them. They understood the flow and level of Chanamma's family's income, and what the light was needed for. They proffered a single solar light system that could be financed by a loan from a local bank, as the upfront cost was too high for the family to afford. Banks are traditionally shy of lending to the poor, however, and the financial institution insisted the family pay a quarter of the cost as a down payment. They would then fund the remaining seventy-five per cent through a loan. Chanamma couldn't afford this. Neither could most of her neighbours.

SELCO intervened on behalf of the villagers and negotiated with the bank. Using grant money they had received from the Renewable Energy and Energy Efficiency Partnership (REEEP), they placed a deposit in the bank that guaranteed the quarter cost of the system. Reassured, the bank loaned the full amount of the system to Chanamma, allowing her to pay for the solar lighting system in small amounts over time. She makes her repayments religiously. Now she has better light, she can roll beedis for longer and her income has increased. Part of this goes to paying off the loan, which in turn has increased her credit rating with the bank. SELCO provides services to maintain the lighting system and Chanamma has access to their technicians in the close-by town of Puttur. The cost of the first year's service is included in the cost of the system. For subsequent years, it is available for a small fee.

SELCO's services are not limited to home lighting systems. In another part of Karnataka, urban Dharwad, the company worked with a local entrepreneur, S F Madlur, to help him set up a business. They'd noticed that the area's street vendors, whose peak hours of business were after sundown, relied on smoky kerosene lamps, petromax lanterns or rechargeable emergency lamps to hawk their wares. The irony was that these low-income businessmen were paying Rs. 15 – Rs. 25 a day for their four hours of poor quality lighting - around five times as much as those who had access to electricity. As the vendors come under the informal sector, they had no route to access electricity legally, and did not fit the bank's lending profile.

SELCO intervened to arrange a one hundred per cent financing loan between Madlur and a local bank, allowing him to invest in a solar battery charging station that charges around twenty batteries. Each street vendor now has a CFL-based light attached to their cart, and rents batteries for it from Madlur on a daily basis. At the end of the day, the batteries are collected for recharging in the solar station. The fee is also collected at the end of the day, and is a price competitive with what the vendors were previously paying for kerosene-based lighting. The entrepreneur makes an adequate income, allowing him to repay his loan with enough surplus to keep him interested in the business. He has even increased the battery bank in size from a twenty light system to a fifty light one. Crucially, the bank now sees Madlur as creditworthy.

These are two examples of how SELCO works. SELCO India Pvt. Ltd., a for-profit enterprise, was founded in 1995 with the mission to provide much-needed access to clean lighting services to the poor: those with little or no access to reliable energy services. SELCO is now a fifteen-year-old company with successful operations across Karnataka.

Image: Chanamma's income has increased with her solar lighting system.

Casting light into shadows

SELCO was founded to challenge three popular myths:

1. Sustainable technologies cannot deliver solutions to the poor.

2. Sustainable technologies cannot be afforded by the poor.

3. It is not possible to run a business with a "social mission" in a financially profitable manner.

SELCO's business strategy, therefore, has pioneered the design and delivery processes that disprove these myths. By understanding the needs of its target markets – be they households, rural farmers, or street vendors - SELCO could create solutions that were sensitive to its customers. To do this, it had to innovate in a variety of ways.

Firstly, the company needed to redesign off-the-shelf solar products to suit particular customer needs, and ensure doorstep and regular post-installation services for these products. Secondly, it had to enable financing of these solutions, so that poor people need not pay the entire cost upfront. SELCO has developed long-term relationships with banks and micro financing institutions of south India to catalyse solar loan portfolios in the banking sector for a market segment once considered unbankable. Thirdly and most critically, SELCO and its employees learn how to link energy, livelihood and income. The loans for SELCO's products and services could only be repaid in the above cases, for example, because Chanamma's income increased and Madlur had a new business to run. Innovation along these dimensions is a continuous process at SELCO and is all in a hard day's work. During the course of its fifteen years of operations, SELCO has created an environment that has mobilised finance into the solar energy sector, and catalysed solar entrepreneurship. This has enabled it to deliver 100,000 lighting systems to the energy poor. Other solar companies are now more easily able to deliver their solutions to similar market segments.

SELCO has created a network consisting of twenty-eight offices across Karnataka, in addition to its head office in Bangalore. The energy service centre is the basic building block; it typically employs five people, including a manager, technicians and commission-based sales staff. This centre markets, sells, installs and repairs SELCO's services. Zooming out, an area manager in each district manages clusters of four to six energy service centres. The area manager also identifies where new service centres should be built. He maintains relationships with local banks, and is

the contact point between head office and the energy service centres.

In total, the SELCO network employs 180 people, and a further eighty business commission agents. SELCO considers personality as much as qualifications during applicant interviews. Managers assess whether candidates are passionate and motivated to work long-term for an organisation like SELCO, where processes and protocols need constant innovation. “We strive for fifty per cent of our employees who are passion-based, and fifty per cent who come in from 9am to 5pm,” says Dr. Harish Hande, founder of SELCO. “Ideally, we don’t want to cross over. If you have more than fifty per cent passionate people, then you have lots of problems in the organisation, and if you have more than fifty per cent who are salary-based, you end up with problems on the mission. So that’s the balance.”

The winding road to success

The initial idea for the company came from Hande’s PhD, which underwent a drastic change following a visit to the Dominican Republic. There, he observed solar micro-enterprises delivering energy services, coupled with micro-credit to overcome financial barriers. He was convinced that this system had the contours of a solution for India, and on his return to the USA switched his thesis focus accordingly. In 1994, in the latter years of his doctorate, he refocused his research efforts to investigating how decentralised solar electricity could be viable in the Indian subcontinent. It was during this time that he met Dr. Neville Williams, founder of SELF (Solar Electric Light Fund), a US-based non-profit facilitating rural electrification worldwide. In 1995, together they founded the Solar Electric Company – or SELCO India.

The first few years were a struggle. Williams’ organisation, SELF, tried to channel $40,000 into SELCO India, but was prevented by restrictions on investments of foreign capital. Williams founded SELCO USA to own and fund subsidiaries in India, Sri Lanka and Vietnam, and in 1996 transferred the ownership of SELCO India from SELF to this new parent company. The same year, they managed to get a conditional loan of $150,000 from Winrock International, a global non-profit organisation.

Funding started to pick up. SELCO USA managed to raise equity investments from European investors, and made an equity investment of $850,000 in SELCO India. It also succeeded in securing a $1 million loan from the International Finance Corporation (IFC), the private lending arm of the World Bank. SELCO India broke even for the first time in 2001 and began to make modest profits.

Eager for more, SELCO’s investors pressured the company into attempting a quick scale-up in 2004. Rather than owning and operating all their service centres, as they do today, the company attempted to create a franchise dealer network. These dealers weren’t loyal to SELCO’s mission to serve the poor, however, and they lead the company to start looking at upper- and middle-class markets, which were still immature. By the end of the 2005-2006 fiscal year, SELCO’s profits had begun to fall.

The company suffered another blow in 2007. Germany introduced large solar subsidies, causing the global photovoltaic cell market to shift focus and spiking the prices of solar panels in India by forty-seven per cent. The company was brought to the brink of collapse and its primary mission heavily compromised. With the help of the IFC, which supported their management, SELCO India underwent a long and arduous journey to restructure ownership of the company. After a legal process, SELCO eventually managed to attract three new investors whose values were more aligned with their own: E+Co, Good Energies and the Lemelson Foundation. All three are not-for-profit, committed to SELCO’s mission to provide energy services to the poor, and open to single-digit returns on their investments. Together they now have a ninety-eight-per-cent-plus stake in the company: an unusual situation of a for-profit company with non-profit investors. SELCO now has a total equity base of $2.1 million, with the IFC remaining as the leading debtor of $0.8 million. “We’ve learnt from our mistakes,” says Hande. “We now do as much due-diligence on the investors as they would do on the investees.”

An Indian institution

SELCO is now considering how the company should grow. It institutionalised its design process by creating an innovation centre and a SELCO Labs within the company in April 2009. They’ve begun to look at energy solutions beyond solar. The hope is to develop solutions for more difficult markets – to go “deeper” into the base of the pyramid[1], rather than merely “widening” their market base. These critical decisions will affect SELCO’s future – both in terms of its further plans and its continued success as a socially-committed company that turns a profit.

[1]The base of the pyramid is a term that describes the largest and poorest socio-economic group. Approximately 2.5 billion people fall into this category.

Fact Box
SELCO India

Who:	SELCO Solar Light Private Limited, founded in 1995.
Where:	Head office in Bangalore, with operations across Karnataka.
Business mission:	Provision of lighting and other energy solutions to those living in the base of the income pyramid.
Track record:	Has delivered 100,000 solar lighting systems.
Clients:	Households, institutions, schools and businesses.
Employees:	180 staff and 80 business commission agents, across 28 branch offices in Karnataka.
Critical Partnerships:	Nationalised and rural regional banks in Karnataka.
Ownership:	98% + stake held by three non-profits: E+Co, The Lemelson Foundation and The Good Energies Foundation.
Current Equity Base:	$2.1 million.
Outstanding Debt:	$0.8 million from International Finance Corporation
Contact:	SELCO Solar Light Pvt. Ltd., Bangalore. Ph: 91-80-26654 509, 26654 510. Email: selco@selco-india.com.

Features to notice:

- It’s possible to build a profitable business providing renewable energy to the poor.
- The poor are bankable, and willing to pay for reliable energy services.
- However, they often need help with financing. Bundling bank loans with a product, allowing payments to be made in instalments, can unlock this huge market.
- Providing customers with access to maintenance services after installation is critical.

CASE STUDY III

Image: Nagarathnamma pours chai from her biogas-powered stove.

Five thousand, five hundred clean cookstoves through biogas

Chickballapur district, Karnataka

In 2005, Nagarathnamma's kitchen looked like her mother's had when she was a child, and her grandmother's before that. The women cooked on a mud stove in the corner of the kitchen, pushing sticks into its embers. It was a laborious process. "We had to go to the forest, get firewood and then cook," Nagarathnamma remembers. "An entire day was wasted. We used to get eye pains, we used to cough…" The wall above where her stove used to be is still blackened with soot, deposited by the thick day-to-day smoke that would fill her two-room house. Nagarathnamma lives in Vadigiri, a small village in Chickballapur district, near the Andhra Pradesh border in Karnataka.

In 2006, a biogas unit[1] was installed on Nagarathnamma's property. It's a domed chamber buried under her yard, with a trapdoor at the top where she loads in the dung from the family's one cow, mixed with water. The dung digests in the anaerobic chamber, producing a gas, and a nutrient-rich slurry. The gas is piped to the kitchen, where it burns cleanly on an adapted stove, replacing her need for wood as a fuel. The slurry from the domed digester is pushed out of its side, and makes a nutrient-rich fertiliser for the family's yearly crop.

"Not only are those [firewood collecting] days free, but it is much faster to cook," Nagarathnamma says, reflecting on the benefits of the biogas unit. "It's much easier to send the children to school in the mornings. We run a small shop and I spend my time there. I can run it more easily now." She no longer has to spend hours scrubbing black marks from her cooking vessels. Through the biogas unit the cow, already heavily depended upon in villages for its milk, becomes an even more important source of income. Its dung creates not just a clean, free cooking fuel, but the time in which women are free to do other things.

"Simply put, your life is easier," says Ram Esteves. His non-governmental organisation, ADATS[2], orchestrated the construction of Nagarathnamma's biogas unit as one of forty-two others in Vadigiri village. In total, ADATS set up 5,490 of these units across Chickballapur district between 2006 and 2008.

Ram points out the implications of having to fetch firewood were often offensive, as well as inconvenient. "The women walk ten or fifteen kilometres and there's a lot of sexual exploitation that happens at the hands of the forest guards," he says. "Then they come back staggering with a huge headload of fuel. It is horrible. So demeaning. So it's not just the practical gender aspect, but I would say to do with self-respect, dignity and all those things. There's a lot of symbolism in these biogas stoves for these women."

"I can't go back to the earlier difficulties now," agrees Nagarathnamma. She says the unit has so improved her life she'd be willing to take a bank loan to replace it, if a break down forced her to[3].

Cattle dung biogas is readily acknowledged to be a highly effective renewable energy system for parts of rural India. However, the cost of building the unit is still beyond the budget of most rural families, especially a family of daily wage labourers. The unit in Nagarathnamma's yard cost Rs. 11,000. To construct all 5,490 units, the project spent Rs. 61.5 million. "You can't touch those kind of numbers with donor funds," says Ram.

This giant project is known as the Bagepalli Biogas CDM Project, after the central town where ADATS is headquartered, and because it was financed by a commercial transaction through the forward sale of carbon credits.

[1]See diagram, page 29
[2]Agricultural Development and Training Society, www.adats.com
[3]See 'uses of capital' in fact box, page 30

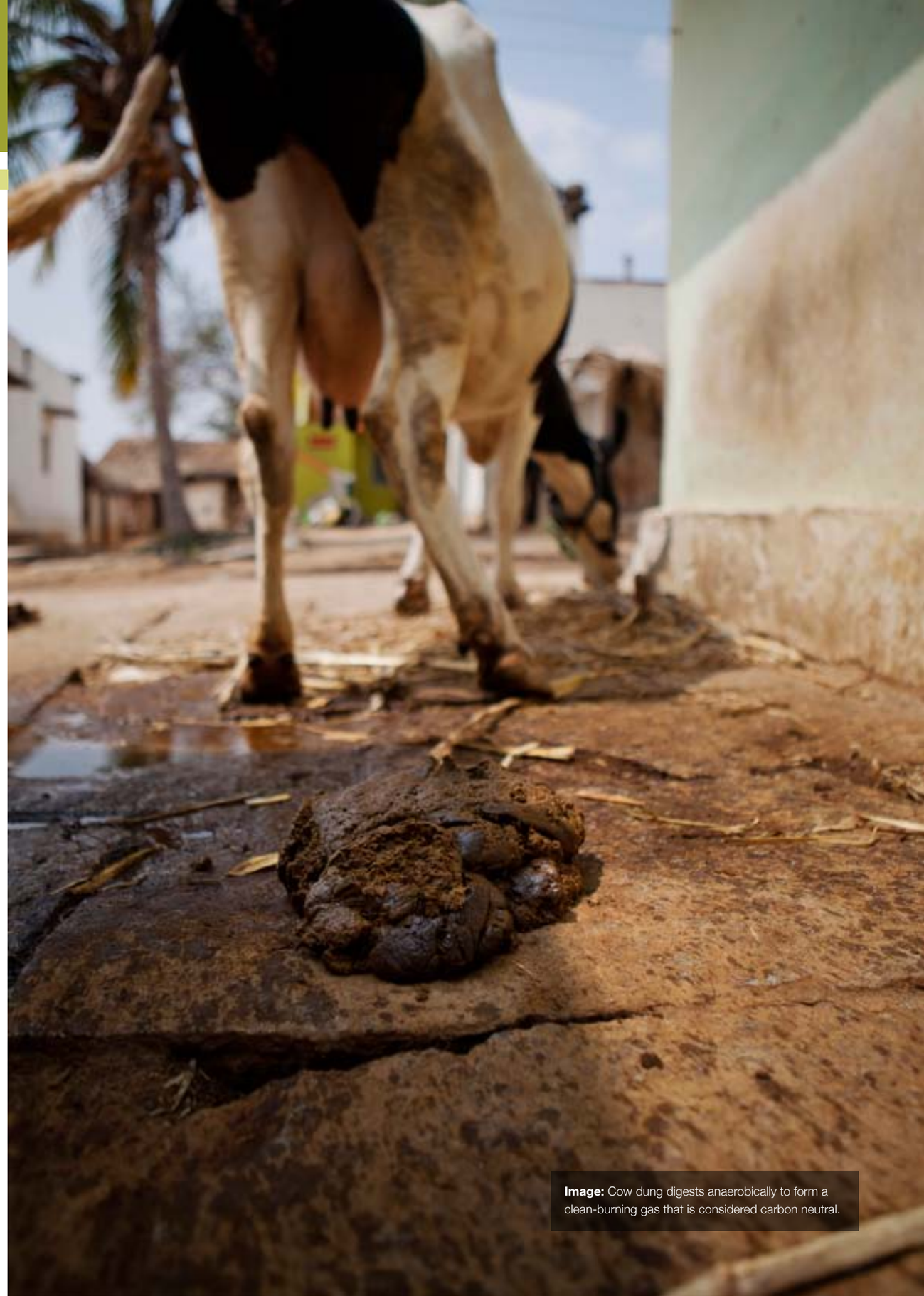


Image: Cow dung digests anaerobically to form a clean-burning gas that is considered carbon neutral.

Image: Construction of a biogas unit in Bagepalli taluk.

Biogas units can generate these credits because they replace the use of kerosene and non-renewable wood[4] for cooking, and so cooking food on a biogas flame means less carbon dioxide emitted into the atmosphere. ADATS received €1.1 million by selling these reductions under a clean development mechanism, or CDM[5], which is aimed to direct investment towards sustainable development in developing countries, whilst also reducing greenhouse gas emissions. This amount was for all the carbon credits the biogas units would create in the first seven years of the project. In line with the Kyoto Protocol, each tonne of CO_2 emission prevented is traded through certified emission reduction (CER) certificates, which are verified by the UNFCCC[6]. Individuals or companies in industrialised nations can buy these certificates to help them achieve their own emission reduction targets. Any further sales of carbon credits beyond this seven-year period ADATS has pledged entirely to women like Nagarathnamma, as income.

The plan for Bagepalli's biogas project was passed to ADATS by a group of climate activist friends.

"We didn't know head from tail of a biogas unit at the time," admits Ram. "We had to learn what the hell this was about."

[4]Wood coming from deforestation is termed non-renewable.
[5]See http://cdm.unfccc.int/, and addendum on CDM, page 111.
[6]United Nations Framework Convention on Climate Change.

Coolie Runnings

Implementing and maintaining such a giant project is a huge challenge, yet the Bagepalli Biogas CDM Project is in its fifth year and shows no sign of failure. The success is almost undoubtedly founded in the strong social organisation that had already been created in Chickballapur district, in the form of ADATS and a people's group called the Coolie Sangha.

ADATS is highly organised, and long established. In 1985 they seeded the Coolie Sangha, an independent community organisation whose name roughly translates as the organisation of daily wage labourers. The Coolie Sangha has nearly 40,000 member families across 902 villages, all poor farmers with little or no land, living in Bagepalli and four other blocks of the district. Funded by an income-dependent 'Sangha tax' from members, it features in almost every facet of its members' lives: from education, to health, to policing, to micro-loans. One of their first actions was to form an advocacy group for Coolie women facing domestic violence, which leveraged peer pressure to prevent future beatings. The organisation has helped reduce rates of cervical cancer deaths to almost zero, raised the percentage of girls in high school (post puberty age) from three to fifty per cent, and has such size and solidarity that they largely control local body elections, based on which politicians act in their interest.

"We have a base," explains Ram of the Sangha's presence in Chickballapur. "When it came to the biogas project, all we needed was to convince the people of its merits. Once we carry our people with us, we have confidence it will succeed."

The Coolie Sangha selected the villagers who would receive a biogas unit on their property, based on which families were willing, and which had the requisite cattle and twelve square foot of yard space under which the dome could be built. This property requirement, and the need of a cow to produce the dung to feed the biogas digester, means that biogas is not necessarily the best method to reach the poorest of the poor: forty-seven per cent of participating families were upper caste, eighteen per cent middle caste and thirty-five per cent scheduled castes and tribes[7]. However, two or three women collect dung from the street for their units as they don't have a cow, and Ram credits the Coolie Sangha with the fact that families with biogas units often let those without use their kitchens. "All of those silly caste divisions have been broken here," he says, waving his hand.

The biogas units were constructed in 339 villages over a period of twenty-six months. ADATS created somewhere between 16,500 and 22,000 days of work for 134 local masons, training 123 of them on the project. Forty-four thousand more days of work were created for local unskilled labourers, though the property owners – who would soon become the owners of the biogas units – often helped for free. Building standards were stringent and self-enforced to ensure a high quality construction that would last: only fully-burnt bricks, stone jelly for concreting and ten bags of cement were used. They knew scrimping would lead to a failure of the dome later down the line.

"Of 5,490 built, only two or three have had cracked domes, and had to be re-plastered," asserts Mario Esteves, Ram's brother and fellow founder of ADATS. He leads the Coolie Sangha masonry team. It's something of a family affair: Ram's son Mikhail is also involved, leading a team that creates computer software for the two organisations. One of these software modules logs details of each biogas unit and the mason who built it onto an online database, replete with a snapshot of each mason squinting in the flash. The records are to ensure complete traceability for any shoddy workmanship, and to encourage a sense of ownership amongst the masons.

Stainless steel stoves were fitted in kitchens, similar to the model used with LPG[8] but adapted to suit the non-uniform flow of biogas. Many 'clean cookstove' programmes exist in India, exchanging a traditional mud *chulha*[9] for one which emits less smoke, but Mario sees little point in half-measures. "Oh, a clay stove, how fantastic," he says, dripping sarcasm. He props a cigarette in the corner of his mouth and pulls reams of monitoring data from the ADATS printer to show us. "You give these people a steel stove like you use in your own house, and then we'll talk."

The CDM requires monitoring of the biogas units to verify that carbon credits are actually being generated. Logging the activity of nearly 5,500 small kitchens is a mammoth task, and again possible here through the institution of the Coolie Sangha. The organisation has a nursery school teacher in every village, who drops by the house of each biogas user to log how many hours the stove is being used for. The information is added to the online databases in Bagepalli at the end of each month.

Daily monitoring is far beyond that required by the CDM specifications, but ADATS and the Coolie Sangha have stakes in the project beyond honouring the financial transaction. "We want to set up a system that works," says Ram. "Because the moment you start using biogas you can't slip back to fuel."

A commercial transaction

It's a long way from the kitchens of the Coolie Sangha women to the global carbon markets. The mechanisms of the Kyoto Protocol stem from a concern to mitigate climate change, as did the actions of the climate activists who drew up the Bagepalli Biogas CDM Project plan. Yet for ADATS, the carbon credits merely provided funds for a development project they feel they would never have been able to afford otherwise. To explain the money, villagers were told their cooking methods were damaging the earth, and a scheme would reward them financially for not polluting. "That is something I feel very, very guilty about," admits Ram. "There are no poor people that are polluting. It is a lie, but CDM forces us to tell that lie. The real problem is not here."

However, the NGO has appreciated the difference between

[7]As surveyed by the Coolie Sangha. Scheduled castes and tribes is a grouping of tribal communities as defined by the Constitution of India. Traits include traditional occupation of a definite geographical area, distinctive culture featuring tribal ways of life, primitive characteristics of occupational patter and economy, and lack of education and techno-economic development.
[8]Liquid petroleum gas, the common cooking fuel in India.
[9]A basic cooking stove, common in less developed areas.

Image: Ram (right) and Mario Esteves of ADATS, Bagepalli.

the usual donor-beneficiary relationship, and the commercial transaction of the CDM. The women who use the biogas units are carefully referred to as end users, not beneficiaries, and Ram specifies that the Coolie Sangha's daily monitoring is to ensure these women are getting a good service. The forward sale of the carbon credits – meaning that the money was received in advance, and used to construct the biogas units – means that the Coolie Sangha women have already sold all the CERs they will generate between 2006 and 2013. Crucially, if the project were to fail and the CERs not be generated, or not be verified and issued into the UNFCCC registry, the contract would be void and ADATS liable to repay the money. Reasons for failure could include floods, faulty construction or migration, but the most tangible risks were societal. Ram also knew those were what they had least to fear.

"We know we're far more efficient than any fly-by-night operation," he says calmly. "Failure would only be because we didn't have the discipline. So, we thought then that this would prod us into the discipline, wherever we are lacking. Commercial money would create that pressure."

Following the success of the Bagepalli Biogas CDM Project, the Coolie Sangha have registered a second CDM project in the district. Carbon credits have been sold to construct a further 18,000 biogas units, in different villages, and building is already underway. ADATS also leads the Fair Climate Network (see below), a support system for NGOs who want to run their own CDM projects in India. The Network has access to a technical team to complete the complex CDM paperwork in return for a fee, and has thirty-three projects in the pipeline. Ram feels the discipline and organisation the process is enforcing on the NGOs is a good thing.

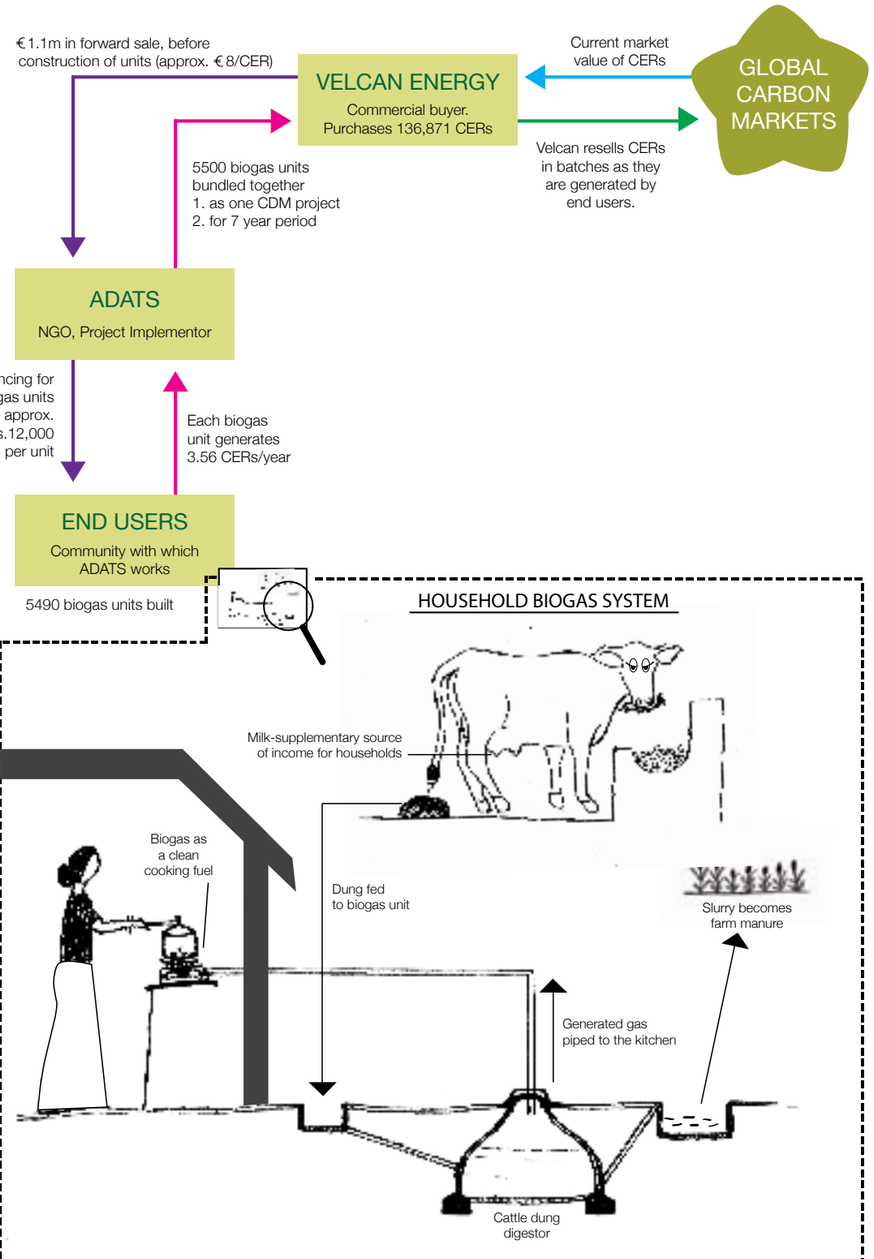
"Ultimately, it's the social issues that are important," he finishes. If there's a match between these and climate change issues, so be it. It there's no match, so be that also."

The Fair Climate Network

The Fair Climate Network is an open platform, initiated by ADATS, which aims to share experiential learning and facilitate grassroots NGOs in tapping carbon funds for sustainable development. The network comprises development workers, climate activists, environmentalists, scientists and professionals from India and abroad. As of today, 500,000 families are being assisted in 36 pro-poor CDM Projects, involving the generation of 686 tonnes of CO_2 reductions. www.fairclimate.com

Image: Without biogas, many women in villages must cook over indoor fires. Collecting firewood can take a day, and smoke and soot cover the kitchen.

Bagepalli Biogas CDM Project



Cow dung ferments to form a gas under the anaerobic conditions of the digester. The gas is mostly methane, and provides an excellent cooking fuel due to its high thermal effeciency. A nutrient-rich slurry is also produced, which can be used as a fertiliser. Biogas is considered a type of renewable energy.

Fact Box

Bagepalli Biogas CDM Project

Where:	Chickballapur district, Karnataka. Five taluks: Bagepalli, Chickballapur, Chintamani, Siddalaghatta, Gudibanda
What:	5,500 Deenbandhu model biogas plants of $2m^3$ capacity each. Fuel: cow dung/gobar. 5,490 built.
Uses:	Cooking, heating water.
Previous situation:	Each family using 2.85 t of wood/year as fuel for mud stoves, of which 2.15 t considered non-renewable (75.6%). 31.2 l /year of kerosene used in addition.
Baseline:	Each five-person household calculated to be generating 3.5 t CO_2/year. Full replacement of wood and kerosene by biogas therefore valued at 3.56 certified emission reductions (CERs) per year.
Project dates:	CDM project for 5,500 biogas units registered 10th December 2005. Crediting period began on 1st September 2006.
Purchaser (participant from Annex I country):	CERs purchased in a seven-year forward sale by Velcan Energy, Paris, France.
Purchase agreement:	Forward sale of 136,871 CERs over seven years between Velcan Energy, Paris, and Agricultural Development And Training Society (ADATS), Chickballapur, Karnataka.
Implementor:	Agricultural Development and Training Society (ADATS), Bagepalli, Karnataka, India.
Earnings:	Forward sale purchases 3.56 CERs per biogas unit per year. Each CER valued at €8.03, therefore over seven year period earnings per biogas unit = €200.69, or Rs. 12,041 at a rate of €1 = Rs.60.
Uses of capital:	Construction costs Rs. 11,089 per biogas unit. Invested Rs. 2500 per biogas unit in deposits, generating Rs. 1.1 m/year to cover maintenance costs.
Contact:	Towfeeq Ahmed, extension worker, ADATS. Tel: +91 90080 18017. Email: towfeeq@adats.com.

Features to notice:

- Clean cook stoves have important impacts on women's lives, both for health and reducing drudgery.
- Accessing CDM finance can be difficult for small-scale projects. Mechanisms should be developed to help those that contribute to sustainable development. See also 'Addendum on CDM', page 111.

CASE STUDY IV

Image: Parama Ram, 23, maintains the solar panels that power a water desalination plant. The plant provides drinking water to around 1000 people per day.

Solar-powered water desalination

Kotri village, Rajasthan

Bhagwati Devi lives near the Sambhar Salt Lake with her husband and five children, in a hut made of mud and grass. When there's work, she and her husband earn up to Rs. 150 a day harvesting salt from the saline lake water. Then they scrape together to pay for fresh drinking water, brought by tankers from a rainwater pond that forms during the monsoon. Nearly two thousand people rely on this pond in the same way. It's only there for eight months of the year, however, as Bhagwati says there are no good rains anymore. The rest of time, the family drinks brackish water from the Sambhar Lake. Bhagwati is seven months pregnant with her sixth child.

"We know the harm of it, " she says, "but there's no alternative." She draws a bright pink *ghoongat*[1] over her eyes, taking them out of the glaring sun. She says she wants her daughters to marry into a different area; one where there is a good water supply.

The Sambhar Salt Lake is India's largest lake, a glittering shallow pool in the desert state of Rajasthan. It's a valuable habitat for birds, including thousands of pink flamingos, but has also had a savage effect on the drinking water supply in the surrounding area. For a stretch of about 125 square kilometres around the lake, touching Ajmer, Jaipur and Nagaur districts and more than 200 villages, the water has become so saline that it has a Total Dissolved Solids (TDS) value of 3000-3500 mg/l. The safe level for drinking is 500 mg/l. In addition to the salinity, the groundwater levels have shrunk dramatically in recent years, say locals.

"Twenty years ago, we would get good rainfall; about 300 or 400mm of rainfall," says Ramkaran of Barefoot College in Tilonia, Ajmer District. Barefoot College has been running rainwater harvesting programmes with villagers for the last thirty-eight years, amongst other development initiatives such as schooling and health care. "But for the last fifteen years, the average has been only 100-150mm."

Ramkaran says that groundwater levels are also rapidly depleting, even in areas beyond the Sambhar's saline reach. It's the Panchayat's[2] responsibility to provide access to potable drinking water, but they suffer from a general paucity of funds, and there is no specific allocation to treat saline water in their budget. In the summers, when people are unable to access water from the ground, families rely on tankers to bring fresh drinking water from afar.

Some of these are provided free of charge by the government, "but not frequently enough and the distribution isn't equal," Ramkaran explains. "People fight over the tankers. Richer families have bigger vessels, so can take more than poor families."

The result is that a currency label on this most basic of rights has fast become standard. Families must pay for private tankers of water to be delivered, if they can afford it. A tanker of 4000-5000 litres of water costs between Rs. 300 and Rs. 500, and can be used up in as little as fifteen days. For people like Bhagwati, the expense is simply not an option.

A sweet solution

There is a group of people here whose story is turning down a different path, however. Forty kilometres from the banks of the Sambhar Salt Lake, in Ajmer district, a pilot scheme has been set up in a village called Kotri. A purification plant was installed in 2006 in the grounds of Manthan, a local NGO whose name comes from an ancient story in which the sea is churned to purge poison and create purity. The plant produces safe drinking water from the salty, brackish water that occurs in the ground. Or, as the locals say, makes 'sweet' from 'salt'.

The purification method used is reverse osmosis (RO), a process that removes large ions from liquid by pushing it through a fine membrane. However, power is required to do this pushing. The RO plant needs six hours of electricity every day, a demand for which the main electricity grid in Kotri could not be relied upon. Unusually, the diesel that substitutes it so often in India was not prevalent in this part

[1]The loose end of a sari when drawn over the head. Typically used by Hindu women in parts of northern India to cover their faces.
[2]A Panchayat is a village council.

Image: Women collect drinking water from the solar-powered plant.

Image: Bhagwati Devi with her five children. Far from the RO plant, the family must sometimes drink the salty lake water. Bhagwati is seven months pregnant.

of Rajasthan. However, the State receives one of the highest incidences of sunlight in the country, capable of generating 5kW of power per square metre and strong for around 314 days annually.

Manthan decided to tap this sunlight to power their sweet drinking water. They applied for and received full funding of Rs. 1.5 million from the Ministry of New and Renewable Energy (MNRE), and purchased full RO apparatus from the Central Salt and Marine Chemicals Research Institute (CSMCRI) in Gujarat. To power the plant, they purchased 2.5kWp capacity of solar photovoltaic panels and a battery bank. CSMCRI came to install the RO plant, and took only six days.

The plant now provides an average of three litres of drinking water per day to around 1000 people in Kotri and the nearby area.

Reverse osmosis works by separating a volume of water into two: one without impurities, and the other with a concentration of all the impurities present in the original volume of water. In the monsoon, the ration of sweet:salt produced is 60:40, dipping to 50:50 in the dry summers.

The plant runs daily between 10am and 4pm, producing 500-600 litres of fresh water an hour. This is used for cooking and drinking, and the 2000 litres of salt water produced per day is channelled for use in kitchens, bathrooms and toilets. Salt can also be harvested from this water to create income, but the villagers currently see little point in a place as imbued with salinity as this.

Kotri's RO plant has also tested a new type of membrane, developed by CSMCRI. It's been functioning successfully since the installation of the plant four years ago[3], whereas former membrane designs would need to be replaced yearly.

Worth its salt

Above its use as a water purifier, the plant seeks to prove two things. One is the potential of solar photovoltaic technology to provide solutions beyond electricity, demonstrating the links between energy access and other developmental factors. The second is a social point. Proving that traditional academic education is not a prerequisite for operating 'complex' solar technology is one of the cornerstones of both Manthan and Barefoot College, who

[3]Greenpeace visited this project in late 2010

Image: A water tanker in Kotri village square. Fetching water is seen as the work of women and girls.

work closely together. A case in point, Manthan is lead by a former night school teacher called Tejaram, and staffed largely by men and women who have not received high levels of formal education, or are from socially stigmatised groups.

In line with this, the RO plant in Kotri has been something of a social experiment. Funding bodies were previously sceptical that this kind of system could be run by a local, rural community. "People said it was high technology, and needed to be run by an engineer from IIT[4], or somewhere like that," says Tejaram. The organisation challenged the assumption. "We said okay, install it in one place, and see if the village can look after it or not." Their challenge bore fruit.

Parama Ram, 23, has been the operator of the RO system since its installation. Born in Kotri and educated up to eighth standard in Barefoot College night schools, his training to run the RO plant took only six days, during the time CSMCRI came to install the equipment. "We took it apart, and put it back together again, and took it apart and put it back together again," he explains. "It was difficult for me at the start, but now I'm fine with it." He lives above the system, and is one of its biggest advocates, personally persuading 100 of the 150 families that now collect the 'sweet' water to trust that the system was clean. Like many of the villagers, he would often have to drink the saline ground water before the RO plant was installed.

"Our knees felt swollen, our teeth were yellow, and we had stomach pains," Parama says of the days in which Kotri's residents would drink the brackish water. "Now, since we have the sweet water, these pains have relaxed, so people know its bad to drink the saline water. Also," he adds, summing up the fundamental difference, "now they have a choice."

Caste in a different mould

The plant has also been used as a tool to challenge discrimination. Caste division is rife in this area, and members of higher castes will often refuse to draw water from the same place as lower castes. This means social standing can have a direct impact on how much water a family has access to. While the plant's limited capacity means only a third of Kotri's three-thousand-strong population can draw safe drinking water from the solar-powered plant, the majority of them are Dalits[5] and landless labourers.

[4]Indian Institute of Technology, a group of higher-education institutes in India oriented to engineering and technology.
[5]A Dalit is a person of a lower caste.

Image: Tejaram walks amongst the piles of salt harvested at the Sambhar Salt Lake, Ajmer district.

"Higher caste people made it, so we needed convincing that it was good for us too, and that it was safe," says Maya Devi, a Dalit and mother of four who draws water from Manthan. She says the groundwater pipeline they used to draw from has been spouting brackish water for the last three years, and the children's teeth would turn yellow and their joints ache from drinking it.

That the water should be available primarily on a pro-poor basis was a decision of the community, as was which of the families should pay for their twice-daily allowance. There is a nominal monthly charge of ten rupees levied, "to change mindsets," says Tejaram, tapping the side of his head. "People here think that they have a right to get clean water for free." In an area where Manthan says the water table has sunk from ninety to 250 feet, this is sadly no longer the case. Those outside of the RO plant's service area must still pay unchecked rates for private tankers, or drink the saline water.

Tejaram admits freely that the plant in Kotri has been a "first-time experiment." Another solar-powered RO plant is now being built in Ajmer district, in a village called Sinodia. It will have an increased capacity of 5kW, to provide water to a greater proportion of the population than it can in Kotri, and the community will be involved in its installation. It will also charge a little more, to generate the salary of the operator. Four similar projects have been approved and are about to be implemented, funded by the Coca Cola India Foundation. Having witnessed the initiative, the Panchayat has also agreed to provide access to 120 more RO plants, at its own cost.

On the banks of the Sambhar Lake, workers have piled earth in small *bundh*[6]*s* around long, flat rectangles of land and filled the slabs with salt water to evaporate in the sunshine, leaving only the mineral deposits. In this area, the main income of the villagers is salt production, as the rains are too meagre to support much agriculture or livestock. Big dirty piles of salt – mountains, almost – dot the land as far as the eye can see, and the flat pools of water reflect the scanty white monsoon clouds. It's very quiet, and very still. Nothing can grow in this water, and salt can't be harvested during the monsoon months either. Tejaram recounts a couple of the many local folk tales explaining how the Sambhar Lake became salty: in each, the salinity of the lake has been the result of a punishment or a curse, never a reward.

We pass empty, half-derelict houses. "See?" Says Tejaram. "People are migrating because the water situation is so bad."

Meanwhile, as the sun sets on Kotri village, groups of women and girls appear on the road to Manthan, cutting tall columns against the horizon with their water pots balanced on their heads. It's the duty of the women to collect water in villages, and many of the girls have embroidered their own rings to pad the bronze- and silver-coloured vessels. Rekha Megwal, 15, gingerly balances one pot on top of the other with her fingertips to bring home enough water for the six members of her family. It's about the average size of a household in this area. She has no idea how the plant is powered, but it hardly matters to her. Now that she doesn't have to walk so far to bring water, she has more time to study.

"Funders said that this project was too expensive to just give water to 1000 people," says Tejaram. "But they don't see families and the change it can make in people's lives.

"If we can give just one family sweet drinking water, in my opinion that project is a success."

[6]Small raised body of earth, built as a barrier to water.

Fact Box

Solar-powered water desalination

Where:	Village Kotri, Kishengarh Block, Ajmer district, Rajasthan.
Type of technology:	Solar photovoltaic panels power a reverse osmosis (RO) process.
Photovoltaic plant details:	2.5kWp capacity solar photovoltaic panels, 24 x 2V batteries producing direct current, booster pump and pressure pump. The plant uses a new design of membrane by CSMCRI, which has lasted four years as of 2010.
RO system capacity:	Produces 500-600 litres of desalinated water per hour.
Funding:	Entirely by grant from the Ministry of New and Renewable Energy (MNRE), at a cost of Rs. 1.5 million.
Input:	Brackish groundwater. The plant is run for 6 hours per day (10am – 4pm).
Output:	500-600 litres of drinking water per hour. During the monsoon, for every litre of salted water put in, 0.6-0.7 litres of drinking water are produced, dropping to 0.5 litres during the dry summer months.
Usage:	Fresh water from the RO plant is only for drinking. The brackish water is used for washing and other purposes. It is also possible to harvest salt from the brackish section of output.
End users:	The plant provides around 3 litres of drinking water per day to around 1000 people, selected by the community to be mostly landless labourers and socially stigmatised groups.
Billing and payment:	Just over half of the 150 families that draw water pay a nominal fee of Rs. 10 per month.
Operation and maintenance:	Managed by Manthan, a social work centre. The technician is a local employee, trained in 6 days to operate the plant. Any severe problems are dealt with by a technician from CSMCRI, at cost to MNRE. CSMCRI also visit the plant once every 3-4 months.Battery replacement required every 6-7 years, at a cost of Rs. 240,000. Membrane replacement will cost Rs. 25,000-40,000.

Features to notice:

- Access to energy is critical for social development. It can also reduce the drudgery of women's lives.
- High level of academic education is not a prerequisite for managing and operating renewable energy technologies.

CASE STUDY V

Image: The RabiRashmi Abasan in New Town Kolkata, West Bengal is a purpose-built solar housing complex that feeds into the electricity grid.

Grid interactive solar housing complex

New Town Kolkata, West Bengal

India is one of the few countries in the world with a government ministry dedicated solely to renewable energy. This central Ministry of New and Renewable Energy (MNRE) has a nodal agency in each state, to promote and deploy these technologies on a more local level. They also administer the roll out of the parent ministry's schemes. Electrifying remote areas through renewable energy is common; emphatically promoting the use of renewable energy as part of an integrated, urban energy landscape is less so. It's rare that a state nodal agency takes on a real estate project.

In New Town Kolkata, the West Bengal Renewable Energy Development Agency[1] (WBREDA) has built 'India's first solar housing complex.' The RabiRashmi Abasan, whose name means solar housing complex in Bengali, is a neat square of twenty-five houses a few kilometres outside of the old capital city. The compound also holds a community centre with a swimming pool, a children's playground and an ornamental water fountain in the garden of each house. The project was conceived and financed entirely by WBREDA, and construction and engineering outsourced to Bengal Development Corporation Ltd. Each house has solar photovoltaic panels on its roof, with a total capacity of 2.1kW, feeding into the state utility's electricity grid. The community centre has building-integrated photovoltaics, or BIPV: window tiles that generate electricity from sunlight.

Other energy efficiency features include passive solar architecture, allowing the houses to remain cool in the Kolkata summers without need for air conditioning. Central open shafts distribute natural light, and allow air to circulate. Hydropneumatic water pumps save energy by switching on only when there is a dip in water pressure, and by operating on varying frequency so only the required amount of energy is used. Each house also has a 100 litre solar water heating system on the roof, distributing hot water to the kitchen sink as well as the bathrooms. Seventeen solar streetlights illuminate the picturesque single road.

WBREDA has retained four of the twenty-five bungalows, while the other twenty-one were quickly sold to private buyers. Most of the purchasers are families and work in IT; some have their own businesses. Only a couple work in the renewable energy industry. Debabrata Dutta, a RabiRashmi bungalow owner, was motivated both by an ideological support of the environmental movement, and by the opportunity to become involved in something that was ahead of its time. He's sure that in the future, all housing projects will have to have some kind of power generation incorporated.

"We are the first set of people who have taken this type of housing, so surely there are some risks," he says comfortably. He is also the secretary of the RabiRashmi Residents' Association, which will soon own all of the community assets of the compound, including the solar technology. "We thought: this is good work. Let us be part of that."

Renewable energy and real estate

The RabiRashmi Abasan demonstrates two things. Firstly, it is a demonstration of how renewable energy technology can be integrated into housing. Secondly, it seeks to develop a real estate market for this kind of housing, and demonstrate to the real estate sector that this can be done in a commercially viable way.

The families that purchased the RabiRashmi bungalows did so for between Rs. 4.3 million and Rs. 4.5 million, thereby just covering WBREDA's Rs. 4 million construction cost for each house. MNRE grants were used to lower costs of building solar components, but no subsidies from the Solar Mission[2] were utilised as construction was before the mission was introduced.

Some time after the houses were built, however, WBREDA gifted one of the four it had retained to the company that

[1]www.wbreda.org
[2]The Central Government scheme will the objective of accelerating and catalysing the solar energy sector in India. The scheme is owned by the MNRE and is part of the National Action Plan on Climate Change.

Image: Housing with integrated energy generation is seen as a concept for future real estate. The RabiRashmi Abasan bungalows are already estimated to be worth 2.5x the cost of construction.

had built the complex, Bengal DCL. They promptly sold it for Rs. 8 million. Battacharya estimates the value of each bungalow is now Rs. 10 million, and anticipates the value will rise further once commercial infrastructure such as shops and markets arrive. New Town Kolkata is currently an area of development: largely empty, though the skeletons of future apartment blocks are already standing sentinel on the horizon. The bungalows of RabiRashmi Abasan are being decorated as families wait for this development to take place. Mr Dutta estimates it will take around one year.

“It is a nice area,” he considers. “A well-planned city. Plus the security and safety of a gated community, and there’s the swimming pool. I think down the line it’s going to be the ideal place to move.”

The energy-generating and energy efficiency measures in the RabiRashmi Abasan will slash electricity costs for residents. The state allows net metering for residential consumers of electricity up to one hundred per cent of a household’s requirements, meaning that bills will only charge for electricity consumption in excess of what the solar panels produce. However, WBREDA is currently dealing with the challenge of net metering the relatively tiny amounts of current that will be produced by the houses. Once the appropriate instrumentation is in place, and the residents move in, electricity from the solar panels replace some to all of that which is needed from the grid. One consultant with WBREDA anticipates monthly electricity bills of Rs. 200-300, as opposed to a typical bill of Rs. 1,200.

The two government bodies that handle electricity regulation and distribution are the West Bengal Electricity Regulatory Commission (WBERC) and the West Bengal State Electricity Distribution Company Limited (WBSEDCL). Potentially, if a household was to produce more electricity than it uses, the solar photovoltaic panels on the roof could become a source of income. However, WBREC is yet to adopt the feed-in tariff for retail consumers, and the WBSEDCL is yet to institute all the technical, administrative and institutional changes necessary to treat household rooftop solar panels as paid independent power producers.

Laying foundations

The RabiRashmi Abasan is a first step in a vision for the future of urban development. “It’s an action research project,” explains Battacharya. WBREDA has retained ownership of one of the RabiRashmi houses, to reassure the Residents’ Association that the nodal agency will be present if any operating or maintenance problems emerge in the future. In turn, WBREDA will be able to witness the interaction between a residents’ association that produces electricity, and the state utility – a new type of relationship. They would also be able to understand the capacities and needs of an association to maintain and manage solar assets in the long term.

Such technical aspects “will be slightly tough,” admits Dutta. Once energy-generating housing is more commonplace, however, he anticipates that the maintenance may be outsourced to property management companies. Solar technology would merely become part of a common maintenance package, along with roads, waste management, and all other utilities of gated communities. “But we don’t know exactly how it will go yet,” he says, shrugging his shoulders. “I am not worried. Let us see!”

WBREDA also plans to use this housing complex to compile detailed measurements on the performance of the solar panels, including how much electricity is generated through different seasons. This kind of data will be useful to extrapolate the impact of integrating solar photovoltaics into the grid, for when housing with solar technology built in becomes more commonplace.

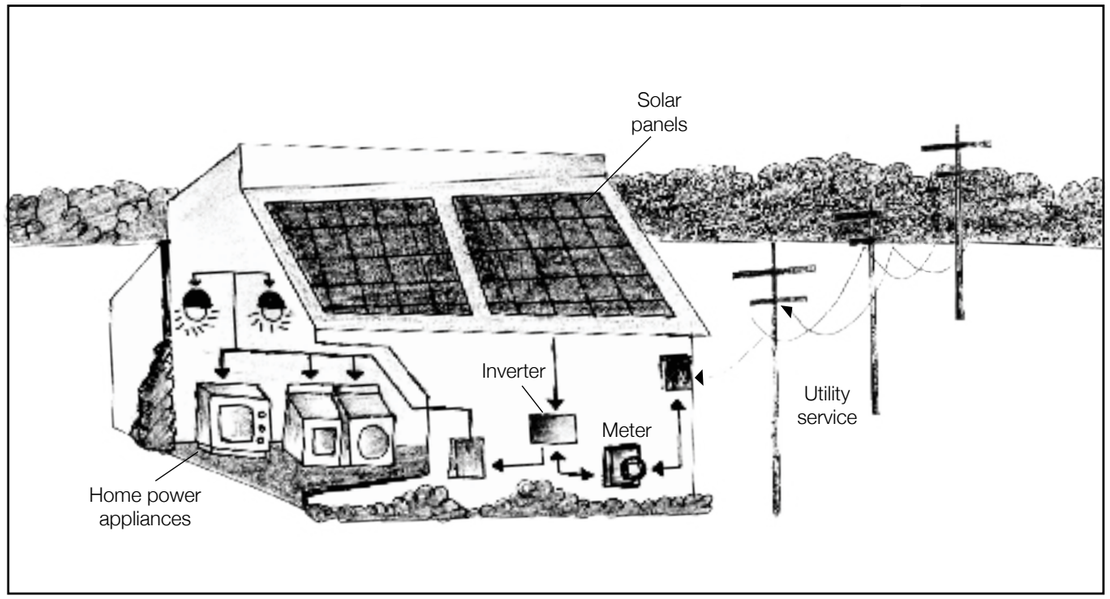
WBREDA envisages a housing sector in which renewable energy is used to holistically solve a variety of potential problems. They’re attempting talks with corporations and municipal authorities, to encourage them to build these technologies into construction byelaws. Their vision is one in which all niches for renewable energy are integrated into urban planning and development, and peak electricity demands are lowered by captive renewable energy generation.

Battacharya talks about hybrid systems in areas with lots of wind, in which a rooftop aero generator can back up batteries on cloudy days when the photovoltaic potential dips. They’re also thinking about biogas digesters[3] to process kitchen waste, and rainwater harvesting to reduce energy bills for pumping water.

“You can consider RabiRashmi as a concept,” explains Battacharya. “It’s under research and development, and there’s scope for more activities. But if we can establish here that LT[4] net metering is possible then it may be replicated throughout India. No problem.”

[3]See biogas system diagram on bottom of page 29.
[4]Low tension, meaning the lower voltage distribution grids.

Residential grid-connected solar photovoltaic system



Features to notice:

- Strong potential for urban planning and construction bye-laws.
- Proactive nodal agencies can demonstrate solutions which may later become mainstream.

CASE STUDY VI

Both of the renewable energy projects in this chapter have been implemented by the Ladakh Ecological Development Group (LEDeG), a non-governmental organisation based in Leh. Much of LEDeG's work is with tribal communities living in the far reaches of the Himalaya, whose wealth lies in the natural resources of the region. Their projects are based on a vision of sustainable development that places appropriate value on that wealth, as well as the cultural heritage of the people there.

In line with this, both energy projects have been implemented in combination with other community development programmes – processing fruits into jam, for example, or building electrified huts for eco-tourism. Training the communities to manage and operate the project is another important feature. By drawing links between energy production and social and economic development, the organisation is demonstrating the strengths of an integrated approach to energy management. The success of these projects is therefore not restricted solely to economics, but also the ability of the system to drive development that can draw these communities into the modern economy, while allowing them to retain a sense of cultural identity.

Image: Operator Konchok Stanzin cleans the panels of the 100 kWp stand-alone solar photovoltaic power plant at Tangtse, Durbuk block, Ladakh. Located 14,500 feet AMSL in the Himalaya, the plant supplies electricity to a clinic, a school and 347 houses in this remote location for around five hours per day.

Micro-hydro power in Udmaroo village

Nubra Valley, Ladakh

In the winters, Udmaroo village is often cut off from the rest of the world.

If you would like to visit during the four summer months, when the deep snows have melted away, you must first navigate the hairpin bends and crumbling edges of the Himalayan highways that lead out from Leh, the capital of Ladakh region. You must cross Khardungla, the 18,380-ft mountain pass that claims to be the highest motorable road in the world, then descend down the other side into Nubra Valley until the flowers start to bloom, and the rocky ground turns to yellow sand. Some hours later, on the way to the Chinese border, the road will run alongside the Shyok River, which becomes deep and rapid every summer with the run-off from the melting snows. A sign by the road reads, “Here, great courage and fortitude is the norm. You are 10,320 ft above sea level.” You will have to park your vehicle, cross the river and walk the last couple of kilometres of the nine-hour journey by foot.

Udmaroo is a bright green triangle in the sloping mountains, cultivating forty-seven of its 457 hectares through carefully channelled waterways. The main income of the village is subsistence agriculture: wheat, barley, mustard and vegetables, plus such an abundance of apricots in the summer that the fruits lie loose in the sea buckthorn hedges. There are no cars, and often no sound to hear but the running of the streams. The only other employment in the valley is through the army - Udmaroo is close to the Pakistan border, and army presence in the area is long established - or in coveted but rare government jobs. The young are now beginning to move out of the villages, looking for non-farming jobs in Leh and beyond.

To date, extending the main electricity grid to a place this remote has not been feasible, and the darkness that extends over the mountains at night can be absolute. Options then are weak and smoky kerosene lamps or diesel generator sets. Udmaroo had a small diesel generator, a gift from the army, but in 2005 the people of the village approached LEDeG looking for a more accomplished solution. The organisation assessed the need in the village, and the feasibility of various types of renewable energy. By 2008, a 32kVA micro-hydro power unit was installed in a glacier stream above the village.

Now, for nine months of the year, Udmaroo is lit and powered by electricity, generated from the power of the moving water. The system is owned and operated entirely by the people who live here.

Tape decks, tea churners and income

“At first we thought it was a joke,” says Rigzen Tsomo, sitting with her legs curled underneath her in her house in Udmaroo. The building is typical of a structure in Ladakh: compounds of grey-white mud brick run through with beams of stripped poplar. These days, however, it’s also common to see a satellite dish poking out from the stacks of drying fodder on the roofs.

Rigzin was one of the many villagers who contributed to the installation of the power unit, both in money and in labour. “We’ve invested a lot of time and effort to bring electricity here,” she says, “and life today is more comfortable. Now we find it difficult to go without.”

Every one of the ninety houses in Udmaroo has an electricity connection from the micro-hydro power unit, through a miniature grid that spans the village. Electricity could be transmitted all day - for as long as the water is flowing energy is available - but the village has decided to only transmit to domestic users after dark, from around 6pm to midnight. The monthly fee of Rs. 90 for this service is ostensibly for use of five CFLs (compact fluorescent lamps use less energy than incandescent bulbs), but in reality there are no restrictions on the amount or type of appliances people use. Only 20-25kVA of the 32kVA micro-hydro unit is used, so there is capacity for extra load. Households use mixers and irons, or even electric butter churners for making the high fat, salty butter tea that people in Ladakh drink to stay warm during the bitter winters. Radios and tape recorders have also been enthusiastically welcomed to the village, and almost everyone has a TV: a way of connecting to the outside world, as well as a source of entertainment. At Rigzen’s house the family watch Mahabharata in the evenings, and her son’s friends come round to listen to music on a clunky tape deck. The boy’s studying to become a monk in another valley, so having him home is a rare pleasure.

Image: Lobzanj Tsephel, Tserinj Ringchen) and Tashi Namgial, elected members of the electricity management committee in Udmaroo.

Image: Members of a women's self-help group, Udmaroo.

In addition to creature comforts, the power unit has also provided seasonal income opportunities for the villagers. Rigzen is a member of a women's group that has purchased a 7.5kW oil extraction machine, and now makes a small income pressing oil from other villagers' mustard seeds and apricot kernels. The small, localised nature of this power generation has the advantage that it can be tailored to customers' needs, and the group were able to arrange for a special cable to be strung from the power unit to the shed where they house the machine. They pay Rs. 15 per hour for daytime electricity, and charge Rs. 80 an hour for their services. Profits are stored in a common bank account, and excess oil is packaged in old half-litre rum bottles, and sold to the army for Rs. 300 each. At the feet of their red machine, bright yellow mustard plants have sprung up from stray seeds.

"It's important for us to be able to earn," says Rigzen, 44. Women always work in villages, but in domestic and agricultural settings their labour is often not rewarded financially. Their business has made a pleasant change. "When we collect the money we feel we have an investment somewhere, and we feel motivated to do more work."

The women of the group are mostly not educated, and have little experience outside of Nubra Valley. The money they're earning means they could change this, if they wished.

"If we're able to generate enough income, one of our dreams is to visit places outside Ladakh," says Rigzen.

"Visit religious places, take some trips. We can also use the money to educate our children better."

With power comes responsibility

Every customer in Udmaroo is a member of an electricity management committee or EMC, though the social and technical governance of the system is the responsibility of an elected body of six villagers. LEDeG is not part of the committee, acting only as a facilitator. Electricity fees are collected by the committee's cashier and stored in a common bank account. Apart from the yearly purchase of five kilos of grease to slick the machine, the only regular running costs are Rs. 3,000 a month for the operator's salary, which allows the committee to collect savings of Rs. 5,000 or more per month. As with most renewable energy technologies, high installation costs are balanced by little to no generation costs. Any post-installation costs that do arise are paid for by the committee's saved revenue.

The elected committee donate about a week of their time every month, free of charge. Most are army retirees, whose previous career gave them an exposure and an education that has come in useful in governing the project.

Image: Rigzen Tsomo and a colleague extract oil from mustard seeds. The machine runs on micro-hydro power.

"Having the MHPU has reduced our drudgery a lot," says Tashi Namgial, the secretary of the committee. All the villagers refer to the micro-hydro power unit casually, by its acronym. "Having electricity available reduces our investments in terms of time, as well as money." Before the installation, villagers would have to travel to powered towns nearby for services that required energy, such as oil extraction or fruit processing. The power unit has helped the village to become more self reliant: in addition to the oil extraction machine, a men's carpentry group says they have doubled their income since buying a machine to carve doors and window frames for Udmaroo. Another women's group has bought a pulping machine, producing 1,500 bottles of apricot jam for sale over the last two years.

Even with the electric irons, the mixers and the micro-industries, Udmaroo still only uses around seventy per cent of the unit's 32kVA capacity. Unlike solar photovoltaic, adding capacity to an installed micro-hydro can be difficult, hence the size of the unit was chosen to be excessive to the village's immediate needs. Yet when nearby villages - without electricity - approached Udmaroo's management committee and asked if they would consider selling some of their excess, the men declined.

"There would be extra maintenance costs, and we think it's safer to keep it for ourselves," says Lobzanj Tsephel, the president of the EMC. "With the current demand, even as the amount of houses grow we see we'll have enough capacity for the next fifteen years."

The reticence to share may be explained by the efforts the villagers put into the set up of the power unit. Firstly, those who were pro the installation had to persuade others.

"Initially there was a lot of resistance," recounts Lobzanj. "Only fifteen households wanted to do it."

"People weren't confident that it would be successful," explains Tashi. "And that meant they weren't willing to contribute their money or labour to set it up."

Between LEDeG and the eager families, the hesitant ones were convinced, and a site high up in the cliff was identified. The villager who owned the land agreed to sell it for the project for Rs. 60,000. Each household then contributed Rs. 1000 – no small amount for a village in which the average income is between Rs. 10,000 to Rs. 30,000 a year.

The power unit cost Rs. 220,000 to set up in total, of which money and time contributed by the villagers covered nearly forty-eight per cent. The remaining funds (see fact box, page 57) were sourced by LEDeG, as grants from European bodies.

Image: Mutup Tashi, operator of the 30kVA micro-hydro power unit above Udmaroo village, Nubra block, Ladakh.

A distribution grid was made with poles of the willow that grows fast in the region, and wires strung by men balancing precariously on beams and ladders. A section of the stream also had to be diverted to run through the MHPU, a “really tough job,” says one villager. “The pipes were so heavy, and we nearly gave up.” All the villagers, both men and women, put in about two months of labour to install the system.

Figuring out the small print

More than two years after installation, it’s interesting to hear the finer details of how the community have adapted to governing their own electricity system. Mutup Tashi is the operator: he mans the micro-hydro power unit on the mountainside above the village, turns its switches and cleans silt from its crevices. The committee manages any problems itself, save one, when the previous operator left the machine running and a part had to be replaced. The equipment had to be ordered from Nepal, and took eight months to arrive.

Mutup has been trained by Lobzanj and Tashi, and has a handbook in the local Bodhi language. Someone has strung ribbons across the ceiling, but he says it can get a little lonely up on the hill on his own. However, Mutup is one of the few in the village who considers he is given enough respect for his job. The elected members feel overlooked.

“People aren’t supportive of what we’re doing!” complains Tashi. “They don’t realise how much time and effort we have to put in.” He says family members tease them that it’s not a ‘proper job,’ unlike paid employment in the army or government.

There’s no question that they may leave their positions, though. “We’ve been trained over and over again [by LEDeG],” he says. “So we feel obliged to take care of the project.” There’s a discernible amount of pride in his voice as he continues: “We also realise that if other people in the village manage it they won’t do it well enough. We’ve worked hard to get to this point, and don’t mind continuing.”

While the EMC may grumble that the villagers do not respect them, they receive no opposition to their work: the bill payment rates in Udmaroo are a remarkable one hundred per cent.

Such honest commitment to the system seems to stem from a couple of factors. Firstly, Ladakhi communities are recognised as close-knit and peaceful. The living conditions in the Himalayas are known to be some of the harshest on earth, and people are used to pulling together to make it through the merciless winters. The EMC has no standard procedure for complaints, as the community is so close they are dealt with on a personal basis. Three widows are given electricity for free, as the community knows they have little source of income. This village has no crime, and doors are never locked.

“I think projects like this help bring a community closer together,” says Tseway Motup, Rigzen’s husband. “We’re happy with the way the operator works, but if there’s a problem that’s beyond him we all go up and help.”

The second factor is that the villagers are well aware how enviable their situation is. The rivers and streams freeze in Nubra Valley for up to four months each year, and the micro-hydo power unit does not create electricity then. So from December to March, the EMC runs a small diesel generator set instead, distributing electricity through the same micro-grid. This provides a direct comparison to the alternative energy paradigm for the villagers. The costs for diesel are much higher: in the winter of 2009-2010 each household has to contribute Rs. 600 for one month of electricity, as opposed to the Rs. 90 they pay for the micro-hydro. By using the micro-hydro for nine months of the year, the village saves at least Rs. 120,000, compared to what they would spend if using only diesel.

“We do think about pollution, too,” says Lobzanj. “In the months we have to use the diesel it creates a lot of smoke.” It’s the first mention of pollution in this story of renewable energy: while mitigation of pollution and climate change are motives for renewable energy in the wider world, here they make sense for developmental reasons alone.

There are government plans afoot to build two 1-2MW dams on the Shyok River, ostensibly to bring electricity to clusters of villages similar to Udmaroo. This would create no thick smoke, and the villagers would not have to manage the system themselves. Would Udmaroo want it? Surprisingly, most people say no.

“Since we’ve invested so much time and effort, I’d be happy continuing with our own system,” says Rigzen.

“But if there are problems [with the grid], it’s the government’s responsibility,” counters her husband.

“But it’s our own source of power and we have control over it,” points out Rigzen. “Whenever we have an occasion like a marriage or death, we can ask that the electricity comes to power it. With the grid, we have no control.”

The members of the EMC – the people who voluntarily give their time to managing the micro-hydro – agree with Rigzen. “If the grid comes we’ll still maintain the micro-hydro, as we have control over it,” says Tashi. “Plus we would have to pay more for the grid.

“Electricity is such an important part of our lives, it’s good to be in charge.”

Image: Women of Udmaroo village, July 2010.

Fact Box

Micro-hydro power in Udmaroo village

Technical details of system:	Capacity	32kVA capacity, presently generating 20-25kVA.
	Head and flow	Net head 54m, design flow 120 litres/second.
	Electric component	415V three phase, four wire system with electronic load governing, live load.
	Total transmission length	3.3km.
Management:	Every customer of the system is a general member of the Electricity Management Committee (EMC) and in turn elects a six-member body to handle management. All members are voluntary	
Costs and funding:	Total cost of micro-hydro system	Rs. 2,218,810
	User cash contribution towards capital cost	Approx. Rs. 1,000 per household
	User in-kind contribution	Unpaid labour for installation
	Remaining installation costs covered in grant funds from European Union (EU), Bremen Overseas Research and Development Association (BORDA) and Groupe Energies Renouveable, Environment et Solidarites (GERES) under the 'Rural Electrification Component' of 'Improving the living conditions of marginalised people in remote villages of Ladakh region,' conceived and implemented by LEDeG. Fruit processing unit funded by Sir Dorabji Tata Trust.	
	Operations and maintenance costs are covered by electricity revenue. EMC income approx. Rs. 8,000/month. Regular outgoings are operator's salary (Rs. 3,000/month) plus small amount of grease for machine.	
End-uses and service levels:	Domestic (90 houses)	Lighting, entertainment (tape recorders, TV, cable TV), kitchen appliances. Electricity provided during the evenings for 6 hours, from 6pm to midnight.
	Non-domestic	Electricity provided on demand, by arrangement with the electricity management committee. a) Four income-generating enterprises (daytime use): i. Women's self-help group runs oil extraction enterprise, pressing oil from mustard seeds and apricot kernels. 7.5 kW, charges Rs. 80/- per hour and is used seasonally for one and a half months per year, ii. Men's group run carpentry enterprise making furniture for local markets – 1.5 kW capacity, used for 3-4 hours per day when required, iii. Women's group run electric flour milling enterprise – 3.5 kW, used seasonally for up to two months per year, iv. Women's group fruit processing enterprise - 746W pulping machine, making 1,000 bottles of jam and 500 bottles of seabuckthorn juice in 2009, and half that in 2010. b) Special occasions such as marriages, funerals and festivals.
Tariffs and pro-poor policies:	Domestic	Rs. 90/month for five CFLs. However, excess consumption is not policed due to high power availability.
	Income generating activities	Rs. 15/hour
	Special occasions	Rs. 50/hour
	Pro-poor policy	Three widows in the village receive free electricity
	A fine of Rs. 500 for late payment exists, though "this is more like a threat," says the EMC president. So far, payment rates are 100%.	
Savings compared to diesel use:	Rs 120,000 savings on diesel fuel to the village as a whole, based on a nine-month cycle.	
Contact:	Mohammad Hasnain, Director, LEDeG. Tel: +91 1982.253221 email: mail@ledeg.org	

Features to notice:

- Community values having control over their own electricity system. Despite the effort required to manage it, they can be sure of a reliable service, unlike customers of the centralised electricity grid.
- Developing productive end uses for these electricity systems is important.

Image: The stand-alone 100kWp solar photovoltaic power plant at Tangtse, Durbuk block, Ladakh.

Solar photovoltaic power plant in Durbuk

Changthang, Ladakh

Durbuk looks like moonscape. It's a block for the purpose of administration, but in reality its twenty-four hamlets and 6000 inhabitants are pretty dispersed. Habitation lies scattered over the Himalayan rock face, bearing intense sunlight in summer and temperatures of under minus forty degrees Celsius in winter. The communities are semi-nomadic pastoral tribes, eking a living by following their livestock to different altitudes with season. It was only a few decades ago that these Ladakhi communities lived in complete isolation, and most life is still lived in tradition. It is a quiet, remote, and inhospitable setting.

Six years ago[1], a solar power plant was built in Durbuk. One thousand three hundred and sixty solar photovoltaic panels, some of the most cutting-edge electricity-generating technology the world has, stand in fenced-in rows at the edge of Tangtse, which is the block's headquarters. The plant is stand-alone, meaning it is not connected to a centralised electricity grid, and has a peak capacity of 100kW. In this arid landscape, 14,500 feet above sea level, the community is harvesting energy.

The electricity situation in Durbuk has always been fairly unique. Firstly, the place is so remote that extending the main grid has never really been an option. In 1993, the block was gifted a 250kVA diesel generator set by the Power Development Department of the state government. It stood in a blackened shed on the outskirts of Tangtse and distributed electricity through a mini grid for three to four hours each day, to houses up to nineteen kilometres away. Houses the grid couldn't reach were gifted solar home lighting systems, or solar lamps from the state government. It's a consideration unusual elsewhere in India, but not here.

The gifts are thought to be due to the politically sensitive location: Durbuk runs along the Indo-China border, and army presence in the area is long established. There are claims that the army also drew power from the diesel set, but their actions are secretive, and the claims difficult to corroborate. Either way, trucks had to bring 48,000 litres of diesel to Tangtse every year, at a cost of Rs. 1.6 million to the state government, plus Rs. 220,000 in maintenance and running costs[2].

Yet the diesel system had problems: breakdowns and unreliable transport, the latter due to the treacherous mountain roads where landslides and deep snows are common. The man who used to operate the diesel set says that the fuel supply would halt for five to ten days in the winters when the trucks got held up. The twenty-three-year-old who operates the solar power plant maintains the diesel wouldn't be available for two to three months of the year. It's an example of the conflicting testimonies and shifting realities that exist in this small and isolated place, which make the community's experiences with such cutting-edge solar technology all the more fascinating.

The greatest asset of the solar power is its reliability. "If the diesel isn't there," points out one contract worker in Tangtse, "the diesel set can't run. The sun is always there." The mini grid was upgraded and extended after the photovoltaic plant was installed, and 347 houses now receive uninterrupted electricity from 5.30pm to 10pm every evening in the winters, and from 7pm to 11pm during the summers. In the winters, when the days are shorter and sunlight weaker, sometimes the supply from the solar bank dips to two hours instead of four, but very rarely below that. The energy captured during the daytime is stored in four battery banks: two long corridors of black box cells in a building next to the plant.

The diesel generator set still stands in its shed as a back up, and people have scratched their names into the soot deposits on the walls. "There's a lot of smoke," nods Thinlay Angchok. He works as a linesman for the solar power plant now, and operates the diesel set only to manage the extra load during Losar, the Tibetan new year. Durbuk's population is almost 100 per cent Buddhist, and celebrates in style. They erect a special tent on the Tantgtse valley floor, pouring lights and music into the still mountain air.

[1]Greenpeace visited Durbuk in 2010
[2]Figures from LEDeG

Image: Dr. Shamim Ahmed can now store polio and measles vaccines on site.

Image: Thinlay Angchok with the diesel generator set that used to power Tangtse. He now works as a linesman for the solar plant.

Bigger consequences than just convenience

The solar power plant has enabled better health care in Durbuk. Its reliability has allowed Tangtse's Primary Health Centre to store polio and measles vaccines on site, as they can keep their refrigerator constantly at the required –20 degrees Celsius. This completes the supply 'cold chain,' a restricted temperature range that the vaccines must be kept within from synthesis to administration. Outside this, the drugs can become ineffective.

"Before the solar power plant, we would bring vaccines by road from Leh and vaccinate people on the same day," says Dr. Shamim Ahmed, the block medical officer. "Now, we have vaccination days in Tangtse every month, and our vans go out to the villages to vaccinate people there. We're on the verge of eradicating polio here."

The clinic uses the electricity from the photovoltaic plant "as much as we can," says Shamim, although they also keep a small diesel generator as back up. Their uses include lights; computers; an X-ray machine; an ultrasound machine; laboratory machines to test liver and kidney functioning; a heater to warm premature babies or those born in the frigid winters; and a toothcare section with electric dental chair and drill. The only rules throughout Durbuk are that electric heaters are not permitted, and that CFLs be used instead of incandescent bulbs. While CFLs are more energy efficient, they are also more expensive, and Shamim has stuck a thundering circular on the clinic notice board:

'It has come to my notice that most of the solar lights or its part and CFL bulbs from the hospital has been taken away by the employee to their residence, leaving the wards and corridors in total darkness, giving haunted look to the hospital and creating a lot of problems while dealing with emergencies at night.'

"The staff come in the middle of the night and take them!" he exclaims. "But now I've marked the bulbs with my signature, so if they are missing I go to their houses and take it back, I shame him." He begins to chuckle. "Then they say 'don't put my name on the notice board!'"

That rules can be enforced by the simple threat of public reprimand is an indicator of the innocence of the community in Durbuk. As in Udmaroo[2], electricity bill payment rates are one hundred per cent, and the plant is run "almost like a family," says Shamim.

[2]See micro-hydro power in Udmaroo village, page 49.

Image: An operator with one of the four battery banks.

Management of a very modern resource

Every customer of the solar power plant is a member of the Renewable Energy Development Cooperative (REDCo), a registered society and non-profit entity. From this pool the society has elected fifteen members to a board of directors, headed by the Councillor. They are charged with ensuring electricity is delivered as agreed to customers, that customers use only the permitted appliances and that fees are collected in the Cooperative's bank account. Shamim considers them to be running it "very nicely. They are good people."

The 'family style' Shamim refers to means his clinic was able to arrange for a special line to bring them electricity for three and a half hours in the day, and the same in the evening. When the operator is late turning on the electricity, the doctor simply picks up the phone and calls him. "But I'm polite," Shamim specifies. "I have to call almost every day, but I don't nag because I can't have him leave the job."

Prudent use of electricity has begun to sink into the community consciousness. It's not uncommon for one person to point out to another that they're using the wrong type of bulb, and the clinic has implemented its own demand side management scheme without instruction. Sterilisation is done by steam, powered by electricity from the solar power plant, "but we do it in a precise manner, like in late evenings when the power consumption is very low," says Shamim. "And we make sure our refrigerators are not running at that time."

Electricity use in Tangtse is not metered. Domestic customers pay a flat rate of Rs. 50 per month, decided on as something that everyone could afford. It's roughly the same as they used to pay for the heavily-subsidised diesel. Ostensibly the fee covers two CFLs per house, "but right now, we don't know how much load people are using," admits a REDCo member. Almost everyone has satellite TV.

The flat fee and the excessive capacity of the solar – only fifty-five per cent of its 100 kWp capacity is currently utilised - could easily encourage carelessness in electricity use. But shouldering responsibility for the plant is causing the community to proceed with caution. "REDCo is run by the people themselves," explains Shamim. "The wise people here know that if something happens, or the inverter gets burnt, it's a problem for them. It's not like a grid, where the government is going to fix it for us. In 2008 one of the

Image: A diesel truck on the Ladakh - Manali route. Diesel is the main fuel for towns and villages in this remotes region, and must be brought by road: often a journey of multiple days. Due to snows and landslides, delays are common.

inverters was not working, and we had a lot of power cuts. It was not a good experience that winter."

However, while REDCo manage and technically own the project, they are not yet fully exposed to the financial risk of something going wrong. This is a crucial aspect of their governance, as solar photovoltaic is the most expensive of renewable energy technologies. The plant was conceived and implemented by LEDeG, who commissioned its design, manufacture and installation to TATA BP Solar in a ten-year contract, which includes maintenance until 2014. The power plant alone cost Rs. 32.8 million, and is part of a larger development project for Tangtse valued at a hefty Rs. 77.3 million. That includes passive solar housing[3] for poor families, formation and training of self-help groups and ecotourism development in Durbuk, as well as Rs. 300,000 per year to TATA BP Solar for maintenance.

Seventeen million rupees of the capital (fifty-one per cent of the plant cost, or thirty per cent of the total project cost) came from the Ladakh Autonomous Hill Development Council, Leh – an elected body to whom the state has devolved a certain amount of funds, and the freedom to direct them. The Council's financial contribution therefore represents a buy-in from the residents on the installation of the plant, as all developmental proposals in Ladakh compete for the same funds. By and large, however, the plant was funded by a mixture of donor grants (see fact box, page 69) that need not be repaid, and include the ten-year grace period in which REDCo can accumulate revenue from electricity fees. With it the committee pays the wages of the plant operators, three young men selected, in part, because they have little desire to leave Tangtse. Their training was part of the contract with TATA BP Solar, and they will be expected to take care of the plant on their own once it expires. In return for Rs. 4,500 per month ("a little low," says one, aligning himself with the majority of wage earners worldwide), the men turn on the current, maintain the batteries and wipe snow from the solar panels in the winter. One sleeps on site.

The managing committee has now begun to act as a micro-financing institution, providing loans to people in Durbuk who want to start businesses. Their income is around Rs. 17,000 per month, and they've taken some initiative to multiply the excess that is left over after their outgoings (maintenance and operators' salaries). Displaying their own business flair, the cooperative charge double the interest rates of the state banks: they know their local location favours them in this remote place. Again, repayment rates are one hundred per cent, and the society now has around Rs. 1.4 million in its bank account. As part of the larger development project, there are plans to start up homestays, a craft shop and eco-huts with this seed money. All would draw electricity from the solar power plant, and hopefully bring income from tourism. REDCo's money will also eventually have to cover the cost of replacing the battery bank (approximately Rs. 6 million), though the first replacement cost is built into the contract with TATA BP Solar, and is due this year.

An ongoing process

"It's a very expensive technology, and complicated, but we're not afraid of it," says Jigmat Yourgial, a REDCo member. Part of the purpose of the ten-year handover period is to allow the community time to become comfortable with their ownership. LEDeG still help out if and when they're needed, and will continue to maintain the cooperative's accounts even after the TATA BP Solar contract has expired. "We want to have our own initiative," Jigmat continues, "but we know we need a little help from LEDeG."

He sits contentedly amongst the geraniums in the street. Solar power is the latest source of light in the fifty-four-year-old's life: when he was a child their lamps were fuelled by yak butter. There's little urgency in Tangste, and Jigmat seems unconcerned they don't yet have a concrete plan for the future. "We'll probably discuss it at the next board meeting," he says, cheerfully. It's the last afternoon of July, but in the quiet clinic the calendar has already been turned to August.

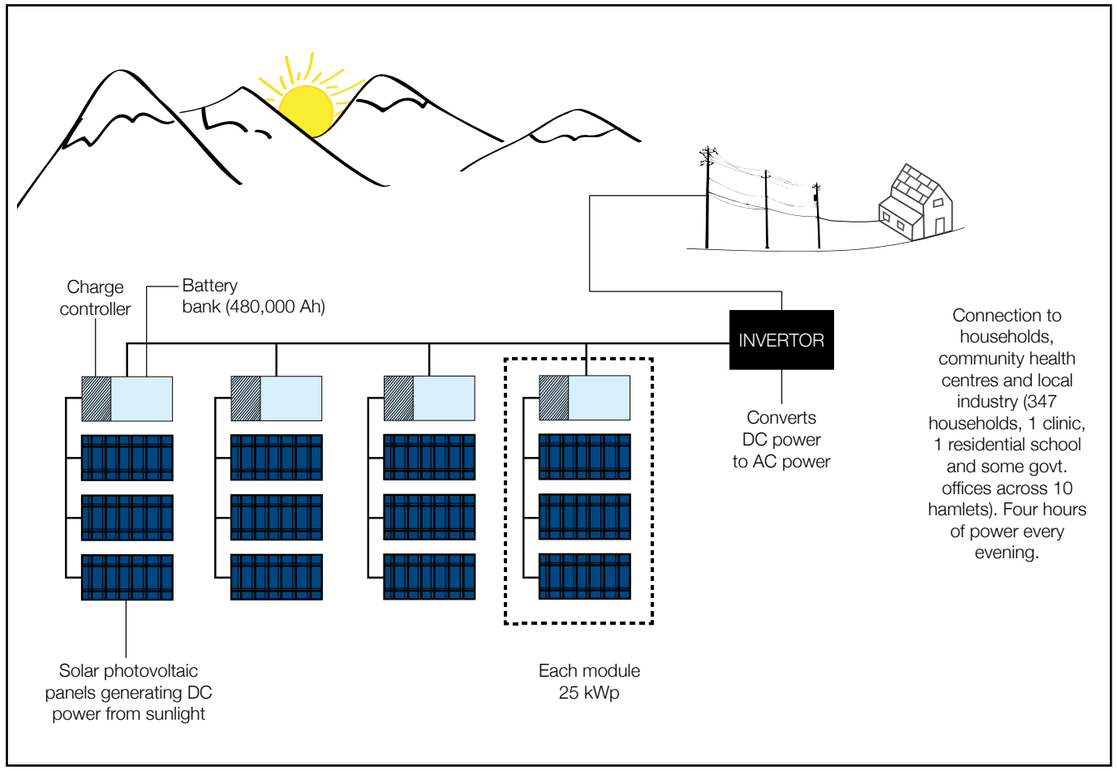
Life in Tangtse continues to tick by. In the battery house, an operator smoothes a picture of the Dalai Lama onto the side of an inverter. When night falls, he presses illuminated buttons on the charge controller and pinpricks of light come from the windows of a gompa high up on the mountainside. The unlikely marriage of this traditional society with such modern technology is a careful learning process, but one that is steadily progressing.

"It can take ten to fifteen years to change a community's mindset," says LEDeG field coordinator Pranai Thapa, commenting on the adjustment to managing the solar power plant. "It's a tough nut to crack. But it can be done, and that's the cement that will hold the project together.

"It's about capacity building. We want to show the community that they don't have to depend on others for their livelihood."

[3]Housing designed to heat or cool naturally as appropriate to the climate, lowering the energy requirements of the building.

Stand-alone solar photovoltaic power plant at Tangtse, Durbuk



Fact Box

Solar photovoltaic power plant in Durbuk

Where:	Durbuk is one of six administrative blocks in Leh district, Ladakh, Jammu and Kashmir. It falls in the Changthang region. The block headquarters is Tangtse, 120km from Leh and 14500 ft AMSL. The SPV plant is situated in Tangtse, and covers almost all of Durbuk.
Plant details:	4x25kWp stand-alone SPV power plant. 1360 panels. 4x120 battery cells of 1000Ah at C10 total capacity. Transmission began on 26th Feb 2005.
Plant Load Factor:	Currently 55%, though 55%-65% is possible.
Management:	Renewable Energy Development Cooperative Limited (REDCo). Registered as a Jammu and Kashmir cooperative society, as per the Indian societies registration act. Comprises of 15 elected community members serving five-year terms. They are responsible for collecting the tariff, ensuring a regular supply of electricity is distributed to customers, checking that customers use only CFL bulbs, and overseeing operations and maintenance of the plant.
Monthly operating revenue from domestic electricity:	Approx. Rs. 17,000
Monthly operating and maintenance costs:	Rs. 4,500 monthly for each of three operators. A 10 year annual maintenance contract with Tata BP Solar India Ltd. worth Rs. 300,000 per year. Includes battery replacement.
Extent of electrification:	347 households, 1 clinic, 1 residential school, some government offices.
Service and tariffs:	Electricity generated almost 12 months of the year. **Domestic:** From 5.30pm to 10pm in winter, and from 7pm to 11pm in summer. Flat tariff of Rs. 50/month, post-paid in cash every six months to a REDCo collector, for 2 CFLs. Most users also have a television.
Clinic	10.30am-2pm, and 6pm to 9.30pm. Bill based on their average usage. Pays post-use in a direct payment to REDCo's bank account.
School and government offices:	Charged at fixed monthly rates.

Capital costs and financing:	Capital cost of 100kWp SPV plant: Rs. 32.8 million Cost of various end use devices, passive solar architecture, manpower and implementation: Rs. 44.5 million. Land requirement: 67,500 x 75 500 ft, built on community land donated to the project. Total cost of project: Rs. 77,258,600. Grant sources include: India-Canada Environment Facility: Rs. 34,848,100 Ministry of New and Renewable Energy: Rs. 17,790,000 Ladakh Autonomous Hill Development Council: Rs. 17,020,500 Ladakh Ecological Development Group: Rs. 1,900,000 The plant was conceived and implemented by LEDeG. TATA BP Solar India Ltd contract was signed in June 2004. It covers design, manufacture, supply, installation, commissioning and comprehensive maintenance costs of the SPV plant.
Contact:	Mohammad Hasnain, Director, LEDeG. Tel: +91 1982.253221. Email: mail@ledeg.org.

Features to notice:

- Local management of technology and resources can take time, but is possible even in the most remote of communities.
- Reliable energy access has important links to health, especially in remote areas.

CASE STUDY VII

Image: Usha Kumari with her mother-in-law Gangamma at their home in Chembu. The family has installed thirty points for lighting from their pico-hydro system.

Micro- and pico-hydro supply chains

Western Ghats, Karnataka

In the shade of the coconut palms, Sridhar Bhatt kneels to turn a small valve wheel, fixed to a pipe that leads to a bright blue box. Stream water rushes through the valve and into the box, gurgling. As the turbine inside begins to rotate with the force of the water, Sridhar watches the needle on the pressure gauge rise to ten.

"If the reading doesn't go up to show the pressure generated by a ten-metre drop in water, I know there's something wrong with the pipes," explains the farmer, tapping the dial. The pico-hydro[1] system has only been on his farm for a month, but he handles it with confidence. It's powered by a diverted section of a stream, drawn from a high point in the hilly land and directed to rejoin it lower down, shortly after the water has passed through the turbine. The force of this movement generates up to 1kW of electricity, which is directed to Sridhar's house through a single set of wires. It's summer now, and the water levels lower, so he comes to turn the system on only when he needs it – between five and nine in the morning, and six and nine in the evening. In the monsoon season, he'll be able to run it constantly.

"We've installed around thirty points for lighting in the house," says Usha Kumari, Sridhar's wife. An electric load governor is fixed to the outside of the house, ensuring there is no change in voltage when appliances are switched on and off inside. "We can use ten lights at a time without a problem," she continues. "We had a solar system installed earlier, but only for two lights. Now I also have an electric curd-churner that I use every day, and a mixer that I use for grinding coconut and rice flour for *idlis* and *dosas*."

Sridhar's frail mother Gangamma shows the giant ancestral grinding stone the family had previously. It looks like it could churn all history, should one use it. "I save a lot of time now," says Usha. "It would be thirty to forty minutes of grinding on the stone, but now I finish in ten or fifteen." The couple's young son is pushing for a television next. "We've resisted so far," says his mother, laughing. "He goes to his cousin's place to watch it whenever he can. He's more or less alone here, too, and grabs the chance for company his own age."

Sridhar's farm is in Chembu, a mostly unelectrified panchayat in Kodagu district, Karnataka. The panchayat is home to 5,000 people (around 950 households) but no buses yet connect it to the local highway. Forty per cent of the population are Dalits[2] or tribal people, and around twenty per cent are landless labourers. Those with land are mostly farmers, growing areca, rubber, cocoa, banana, coffee and a little bit of cashew and paddy. An average landholding is three to five acres. There are many such panchayats in India's rural interior.

"We've been applying for electricity for the last twelve years!" says N. V. Krishnappa, the panchayat president. "We even applied under the RGGVY[3] four years back and were informed it's been sanctioned for us – but there has been no progress on the ground. Most villagers use kerosene for lighting needs." He describes how the panchayat's income from taxes is mostly spent on providing water to households, and the funds from central government are tied to overheads such as roads, housing for the poor, and schools. "And rainfall's very high here so we spend a lot on roads and gutters," he adds. "We'd potentially like to install community micro-hydro systems to bring electricity, but financing is a huge challenge." His colleagues nod their agreement.

With the State unable to provide electricity, those residents of Chembu with land and access to flowing water have begun to install their own private pico-hydro systems to bring power. Thirty-five 1kW systems have been installed in the panchayat by Nisarga Environment Technologies, a company that delivers renewable energy systems and efficient cooking stoves to remote rural areas. This pico-system is Nisarga's primary revenue driver, specifically

[1]See page 11 for hydroelectric size classifications.
[2]A Dalit is a person of a lower caste.
[3]The Rajiv Gandhi Grameen Vidyutikaran Yojana, or RGGVY, is the Central Government scheme to provide electricity to all rural households, primarily by extension of a centralised electricity grid.

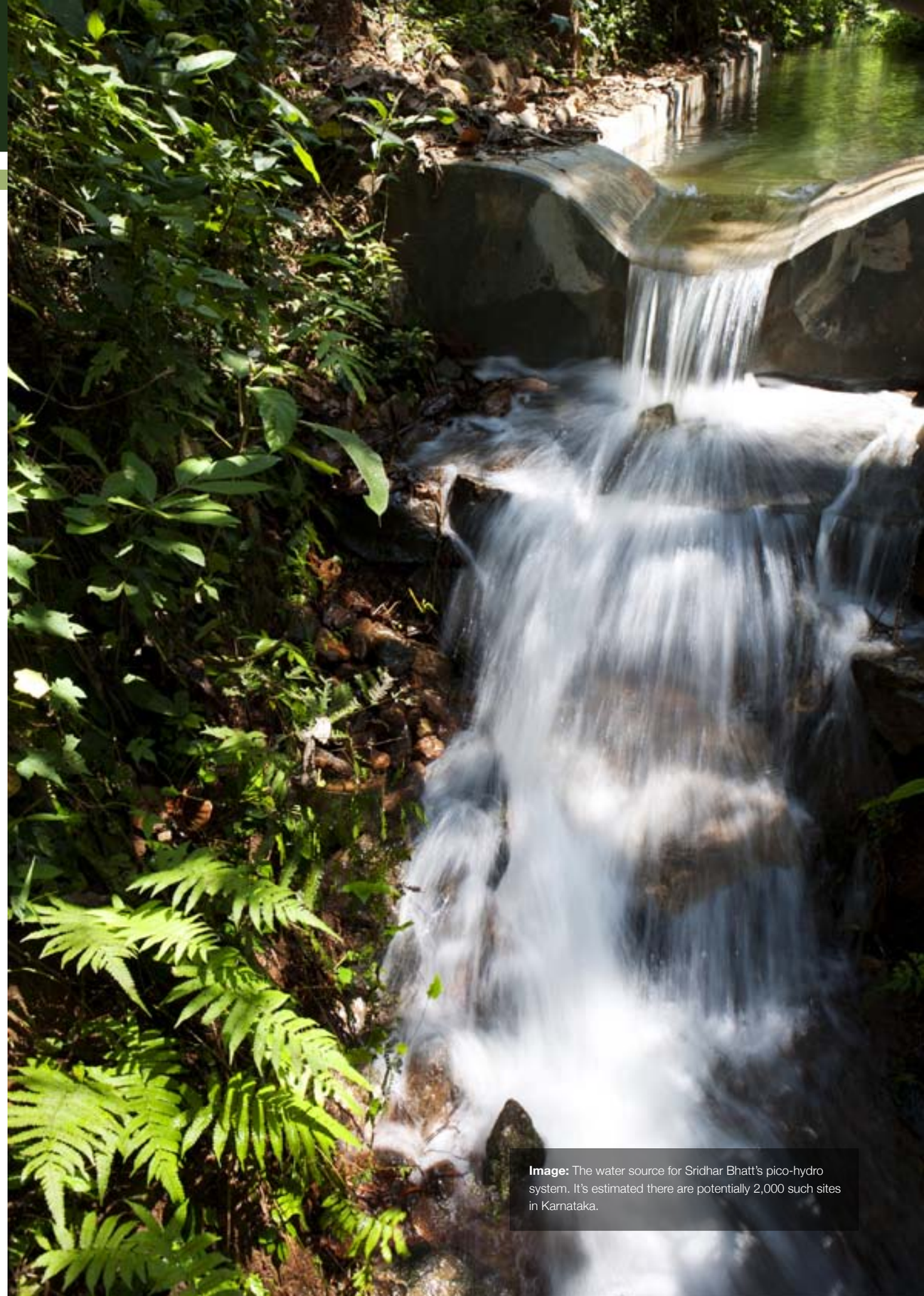


Image: The water source for Sridhar Bhatt's pico-hydro system. It's estimated there are potentially 2,000 such sites in Karnataka.

Image: Homes lit by pico-hydro units in Chembu.

designed for use in the hilly regions and able to operate in a wide range of field conditions. “It’s a big boon for us in Chembu,” says President Krishnappa. Three hundred have so far been installed across the Western Ghats of Karnataka.

Good, hard fieldwork

This tiny, hardy hydro system is the result of an intense two years of field-driven research and development. Sampath Kumar met engineer D. R. Muralidhar by chance in 2005, when the two were sent to work on the same micro-hydro project, which was being implemented by the civil society organisation Sampath worked for. In 2006 the two men formed a company called Prakruti Hydro Labs, with the intention of developing small-scale, hydro-based resources. Prakruti was different from earlier civil society initiatives in its conviction that the approach had to be businesslike, and generate economic value for all players in the chain of engineering, manufacture and delivery of the systems.

“It is a completely wrong perception that micro-hydro does not require engineering,” says Muralidhar. “We’ve used sound engineering principles, and designed products that can operate constantly with one hundred per cent load factor.”

The company has engaged with different players – the electronics, generator and mechanical engineering industries – to develop robust components for their products. “They’re virtually fit-and-forget,” continues Muralidhar. “They can also be adapted to many different types of head and flow, as getting accurate measurements for sites is often difficult.” The system on Sridhar Bhatt’s farm, for example, has two feed pipes as opposed to one, which compensates for the relatively short ten-metre drop of the water.

Each unit built by Prakruti undergoes rigorous testing at their Bangalore facility before it is sold. Developing such a robust, maintenance-free product has driven up the price of Prakruti’s system compared to others on the market, yet customers don’t seem to be deterred. The hardier, more expensive systems have less need for post-installation services, which can be prohibitively costly in remote locations.

“Some of the critical reasons earlier [civil-society-driven] micro-hydro projects have failed are the absence of these services,” says Sampath. It’s an aspect that has caused at least forty households to discard their earlier systems, and reinvest in Prakruti’s pico-hydro. Their strongest form of marketing is word of mouth.

Image: Ganesh and family at home in Chembu.

How will the poor pay?

An ingenious financing model has developed with the product. Very little of the target market (the rural, and the energy poor) can afford micro-hydro systems, which cost around Rs. 100,000 (see fact box on page 81 for cost breakdown). Almost the entire cost of the system can be covered by a scheme from the Ministry of New and Renewable Energy[4] but the subsidy is released only after installation. The prospect of taking a private, commercial loan to buy a system, and then having to later negotiate the subsidy paperwork alone, was proving a deterrent to many potential customers. Prakruti’s breakthrough in late 2008 was to offer the finance as a package with the product: anyone who bought a pico-hydro system would also receive a bank loan and later a subsidy, which the company would apply for on their behalf. Prakruti’s costs in taking all this paperwork would be bundled with the cost of the product.

It was a long and arduous process for Prakruti to build a relationship with KREDL[5], the agency administering the relevant subsidy in Karnataka. They soon found the effort of sustaining the relationship with the agency was distracting their engineers from developing the technical aspects of the product. So they decided to multiply to conquer: it was agreed that an employee who had spent time on the KREDL relationship, a Ravi S. Gownder, would branch out with his own firm. He founded a dealership firm[6] that focused on the delivery of the product, end consumer financing and post-installation services. Hence a supply chain was created that is central to the successful delivery of the product. Prakruti is now free to innovate with the product’s development, and is in the process of creating grid-interactive small hydro models of higher capacity (up to half a megawatt).

Nisarga has developed these initial strategies for financing into robust working relationships with local banks, and there are now two more dealership firms that deliver Prakruti’s pico-hydro product across the Karnataka hills. Delivery of the product is tied to both a loan from the local banks, and the later release of the subsidy from KREDL. Nisarga estimates this has opened up 2,000 potential sites for pico-hydro across Karnataka.

[4]Upgradation/Development of Water Mills Scheme.
[5]Karnataka Renewable Energy Development Limited, the state nodal agency of the Ministry of New and Renewable Energy, administers the Upgradation/Development of Water Mills Scheme in Karnataka.
[6]Nisarga Environment Technologies.

Image: A typical Chembu landscape. There is plenty of opportunity for micro- and pico-hydro systems in this lush setting.

Image: Farmers (right) are helped to apply for loans by bank clerks (left) in the offices of Karavalli Renewable Energy.

In the office of Karavalli Renewable Energy, the pico-hydro dealership in the southern hills, the scene is lively. An extra table has been crammed into the small room and two harried-looking bank clerks are working through piles of paperwork with farmers. The clerks have been sent from their office in Shimoga town, some 200 km away, to set up loans for customers of the pico hydro system. It's rare that the bank comes to the farmer, and a testament to the strength of the relationship with Karavalli.

"After installation, it can take up to a year for the subsidy to be released, so there has to be capital to finance the systems upfront," says Puttanna Gowda, who works for Karavalli. "Farmers can't afford this, so we've tied up with two Farmers' Cooperative Banks to enable loan availability for our clients.

"We'll then apply for the capital subsidy on behalf of the client, submit all requisite documentation, get sanction, complete the installation and submit proof of installation. Then in bundles of multiple systems the subsidy is released by KREDL in the name of the clients. We ensure it is paid out by cheque to the same bank from which the farmer has taken a loan. The banker cuts the outstanding loan amount and returns the remaining to the farmer."

Mundugaru Subhramanya Bhatt, a farmer with eight acres about an hour from Chembu, says he has an electricity connection, but it's so useless as to be negligible. "I'd invest in this system even if there wasn't a subsidy," he says.

Other customers disagree. "Maybe five per cent of Chembu could invest with just a loan, but for the larger populace, this is a subsidy-driven market," says Sahana Kantabail, a journalist living in Chembu. She owns a pico-hydro system from Prakruti, and has also published a number of articles on the systems in local, regional and national newspapers, in both Kannada[7] and English. "Even for farmers with significant landholding such as ourselves, the agricultural economics can be fairly hand-to-mouth. Our primary crop, areca nut, is dropping because of a fifteen-year-old disease that continues to spread. Any surplus income in this area will be invested in something that improves agricultural productivity, such as better irrigation systems." Water is precious, and irrigation is its most valuable use. The fact that electricity is relative to the availability of water – though the systems don't use up or pollute water in any way – has introduced the concept of energy efficiency in the dryer summers. People are more conscious that they should only use electricity when they need to.

[7]The language native to the State of Karnataka.

Image: Ganesh of Prakruti Hydro Labs explains his pico-hydro system.

A fresh approach

Prakruti's pico-hydro system seems to be opening up a market with a lot of potential. Ganesh, a farmer of areca nut and rubber in Chembu, also works as Nisarga's point person in the panchayat, both for business development and after sales service. He was introduced to the company when he became its first customer there. "I was always tinkering with micro-hydro systems anyway, as many farmers around here do," he recalls. "I'd make turbines out of cycle wheels bolted with tumblers, and use belt drives from that to run jeep alternators that would charge batteries for lights in the house. Of course, this product is far superior."

Ganesh was impressed by the efficiency and low maintenance of Prakruti's system, and when they came to Chembu was excited enough to "start engaging with them not only as their customer, but as their colleague".

"We look for the right attitude in employees, rather than just the right paper qualifications," confirms Muralidhar of Prakruti Hydro Labs, from whom Nisarga and the other two dealership firms have inherited many values. "They don't even necessarily have to be graduates. At the moment we're building our teams around young people who have the basic skills but perhaps a lower level of education, such as a diploma." The employee who installed the system at Sridhar Bhatt's house, for example, is just twenty-one. He has been working for Nisarga since he completed his diploma at age nineteen at a local industrial training institute. It's through the dedicated enthusiasm of people such as this, and the innovation of companies such as Prakruti, that formerly forgotten houses deep in the hills are now being lit up.

Fact Box

Micro- and pico-hydro supply chains

Who:

Parent company: Prakruti Hydro Labs, Bangalore.
Founded by Sampath Kumar and D. R. Muralidhar
Daughter dealerships:
1. Nisarga Environment Technologies, Shimoga (central hills of Karnataka),
2. Karavalli Renewable Energy, Belthangady (southern hills of Karnataka),
3. Canara Renewable Energy, Sirsi (northern hills of Karnataka).

What:

A 1kW pico-hydro system, developed by Prakruti Hydro Labs, can operate on 10m-60m head and 4-60 l/s flow rate.

Market size:

Prakruti Hydro Labs and its dealerships estimate approx. 2000 sites for the 1kW pico-hydro system in Karnataka.

No. of systems installed:

250 as of Jan 2011

No. of loans disbursed:

Approx. 220, two thirds of which have been repaid as of Jan 2011

Product costs and financing:

Per household/product:

Item	Cost/Rs.	Source of money
Civil works and piping	20,000 – 60,000	Customer
Electromechanical equipment (turbine, generator, load controller)	91,750	Subsidy from KREDL. Bridge loan from bank until subsidy release
Wiring and basic end use devices	15,000	Customer

Financing details		
Loan disbursed by banks	91,817	@16% interest for a period of up to 1 year, no early repayment fees
Membership share in cooperative bank	525	Customer pays this at the time of loan process
Loan documentation fee	2,900	Customer pays this at the time of loan process
Subsidy amount	110,000	Paid by KREDL under the “Upgradation/Development of Water Mills” scheme after completion of installation.

Turnover of Prakruti Hydro Labs:

Rs. 3.7 million in 2009,
Rs. 6.8 million in 2010 (close to 100% growth).

In 2011 PHL plans to become a Private Limited Company, and is seeking equity from friends and relative networks.

Contact:

Prakruti Hydro Labs: Tel: 080 26860077. Email: prakrutihydro@gmail.com.

Ravi Gownder, Nisarga Environment Technologies.
Tel: 08182 40174. Email: ravi_snisarga@rediffmail.com.

Features to notice:

- Bundling finance and financial services for end users (here, a bridge loan and access to subsidy) is critical to drive uptake of decentralised renewable energy.
- Post-sale maintenance services must be available to sustain decentralised renewable energy.
- Sustainable supply and delivery chains effectively place RE products where they are needed - and creates local employment.

CASE STUDY VIII

Image: Solar thermal water heaters on the roof of Holy Family Hospital, New Delhi. The technology is owned by an energy services company which sells hot water to the hospital.

Supplying energy services
Holy Family Hospital, New Delhi

When it comes to energy, what does the general public want? Is it important to them to be able to produce their own, and talk of current and voltage? Or do they care only for the services – heating, lighting, entertainment - that this energy can provide them with?

S. Srinivasan of Trans Solar Technologies, New Delhi, is of the opinion that it's the latter.

"It's not within the reach of normal people to understand and access the technology to power their own homes," he says. "To know what their power requirements are, what kind of technology they should go for, and so on. Renewable energy also has high capital costs, so is not within the capacity of most.

"So, instead, my company promotes energy services."

Trans Solar Technologies (TST) began in 2001, when Srinivasan returned to India after working for a microturbine technology company in the USA. His business started simply in sales of renewable energy technologies, such as wind turbines and solar photovoltaic panels, but later diversified to become an Energy Services Company, or ESCO. "It's the first in India," he says proudly. The business model is one Srinivasan had been exposed to in the USA, but lack of capital prevented him from starting his business as such.

Under the ESCO model, TST pays the costs of the technology, installs it on the premises of the customer, and charges the customer only for the services the technology provides: hot water, for example, or electric light. The customer benefits as they don't take the risks of investing in the technology, yet have an assured service. The company benefits by setting a tariff for the service that will ensure it an acceptable return on its capital investment.

On the roof of the ward

Holy Family Hospital in Okhla Road, New Delhi, is the site of Srinivasan's first venture as an ESCO. The hospital was previously using piped natural gas to heat water in its boilers, because it was cheaper than using electricity. With room for 300 inpatients, the hospital had a hot water requirement of 20,000 litres per day, and their gas bill was running at Rs. 60,000-70,000 per month. In the winter months, it went up to Rs. 90,000.

"I spoke to some five or six companies about solar water heaters, but their main concern was to sell the product," says Sunny George, the hospital's maintenance officer. Quoted costs to buy the technologies were Rs. 1.8 - 2.4 million, with a warranty of only one year. In other words, too high for the charitable hospital.

The "partnership" ESCO model that Srinivasan proposed, explains Sunny, would instead save the hospital both the cost of the solar water heaters and the responsibility of looking after them. The two men spent seven months working out the terms of the contract together, before presenting the proposal to the hospital director. The seven-year contract held that TST would provide the hospital with up to 22,000 litres of water per day, heated to a minimum of sixty degrees Celsius, for a cost of Rs. 55,000 per month. Water was already provided to the hospital free of charge by the State. If more hot water was needed, or the day was very cloudy, a gas boiler (and the gas line installed previously) could be used to heat the liquid fully. TST would then reimburse the fuel costs to the hospital. In practice, this is rarely needed: on a sunny afternoon in the monsoon season the water usually reaches at least seventy degrees.

The tariff was agreed upon as one mutually beneficial to both parties. Holy Family Hospital would save between Rs. 5,000 and Rs. 35,000 every month on their previous gas bill, and TST would make a handsome return on its investment (see fact box for details). It was a win-win situation, and the director accepted. TST partnered with a private funding agency to access the Rs.1.8 million cost of the hospital's hot water system, and one hundred flat plate collectors[1] were installed on the roof in February 2009. The old gas boiler system was adapted, and hot water distributed to hospital departments through the same pipe network.

[1]A common apparatus for heating water using solar thermal energy.

Image: An operator employed by Trans Solar Technologies maintains the equipment on the hospital roof.

“See, as a customer,” explains Srinivasan, “the hospital wasn’t bothered about the technology. They require around 20,000 litres of hot water every day, and that’s the end of it.”

Holy Family Hospital had owned some solar water heaters about twenty years before, when Sunny was still in college. A problem emerged, however, and the water never heated properly. Unable or unwilling to tackle the maintenance, the hospital scrapped the panels in favour of a gas boiler. Sunny looks embarrassed at the hospital’s easy surrender under the previous maintenance officer. Without some determination, he admits, initial costs and financial risks can be a barrier for organisations investing in renewable energy. Now that their system has been set up, however, he is gleeful about the hospital’s savings.

Once the seven years of the contract have passed, there are three options:

1. TST sells the technology to the hospital at the token price of Rs. 50,000 and walks away. The hospital is left with ownership of the system, and any maintenance costs or financial risk that comes with it. TST will have regained their costs, and made some profit (see fact box, page 89).

2. Pleased with the service, the hospital chooses to renew the contract, but this time purchasing the hot water at a cheaper price than in their previous contract – Rs. 20,000 per month, for example. TST accepts this, as the system has already been installed and the capital costs returned. If the hospital’s hot water requirements increase, the system can be expanded and the cost of that factored into the tariff.

3. Technology may have advanced by the time the first contract elapses. If so, TST removes the existing solar thermal system, replaces it with a new, more sophisticated technology, and begins a new contract with the hospital.

A small-scale approach can pay dividends

More benefits have come as a result of the close working relationship. The operator Srinivasan employs now also takes care of the gas autoclave boiler, the effluent treatment plant and the sewage treatment plant on the hospital premises. The hospital benefits because they pay Srinivasan a service fee that was less than they had paid the previous company; Srinivasan benefits because he received the contract at no extra labour costs. It’s the kind of tailor-made solution that can often result from small-scale, decentralised projects, and Srinivasan obviously enjoys piecing things together in this way. He negotiates the hospital corridors confidently, pointing out his company’s touches.

TST and the hospital are now also in talks to meet the hospital’s electricity requirements through an ESCO solar photovoltaic system. Electricity provision by the central grid is good in this part of New Delhi. “One hundred per cent available,” says Sunny, when asked about it. “Though of course,” he adds, “being a hospital we have to have a backup.” The hospital, however, sees the opportunity for something cheaper. As with the hot water system, the contract would be a result of their specific circumstances.

“See, our load pattern varies,” explains Sunny. “In summer, we draw around 1MW, sixty to seventy per cent of which is for air conditioning. In winters, the lean period, our load is only around 360kW.” Yet the hospital has a sanctioned load of 650kW and must pay for this monthly, though they often use less. When they draw more, they must pay a fine, which means their electricity bill vacillates between Rs. 900,000, and a steep Rs. 2.2 million each month. Now they also want to replace the long lines of fans in the rooms with air conditioning units, which would increase their load further.

On request, Srinivasan will come up with an ESCO proposal for a solar photovoltaic system. He’s calculated that there’s still enough space on the roof to host a 1MW plant, which could run their lighting, fans, and air conditioning and biomedical machines “It could reduce our lighting costs by half,” considers Sunny.

Word about the ease of the ESCO model has spread, and Srinivasan is now in the process of installing a 5kW solar photovoltaic system in St. Mary’s Convent School in Rohtak, Haryana, about one hundred kilometres from New Delhi. Outside the city, the electricity provision from the grid is very poor during the day, and the school is currently paying around Rs. 40,000 per month to run off diesel generator sets. Srinivasan is installing the system of 5kW to provide for their electricity needs (daytime fans and lights), in return for a monthly fee of Rs. 30,000.

If there is less sunlight on a given day and the capacity of the solar PV system dips, the school’s power will be topped up by back-up batteries, which charge from the grid during the night when electricity is available, but not being used by the school. The system will cost TST Rs. 1.2 million to install, and very little to maintain. Srinivasan can expect to get his costs back in just over four years, and will make Rs. 400,000 profit by the end of the five-year contract.

A commercial business

Reduction of carbon emissions is now no longer seen as an act of social responsibility for businesses, but is becoming a part of core strategy to reduce environmental costs. Despite this, neither Srinivasan nor Sunny have considered their shrinking carbon footprint at any stage. “It just happened,” shrugs the maintenance officer. “This is a commercial

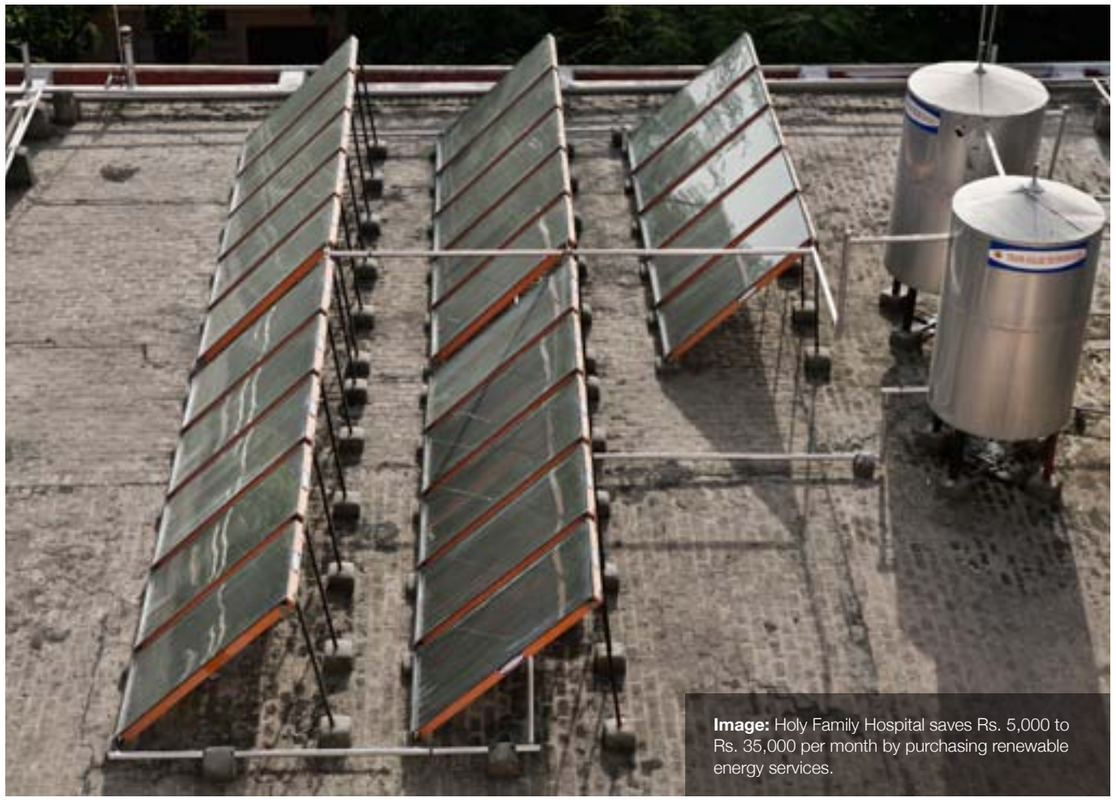


Image: Holy Family Hospital saves Rs. 5,000 to Rs. 35,000 per month by purchasing renewable energy services.

business - one hundred per cent,” confirms Srinivasan. The two men often finish each other’s sentences. “It has to make firm financial sense or I see no point in doing it.” TST will now also replace the hospital’s worn-out boilers under the ESCO model, some of which will be operated by gas, and some by solar, depending on which technology is more suited to the type of usage.

The greatest barrier to growth for an ESCO is the high capital intensity. To make deal after deal like this, TST would need a huge upfront investment. “Human resources and knowledge are absolutely no problem,” he says. “Capital is the one and only problem I am facing at present. I can multiply this business exponentially if capital is available.” So far, costly capital has been raised per project through private funding agencies. “Small-time people like us face a lot of problem with bank funding. Bank finance would be cheaper, but they always demand collateral.”

Renewable energy subsidies could bring down these costs, though none were used to commission the Holy Family Hospital project. “But they are also too time consuming,” says Srinivasan, describing how it can take between six months and a year to receive a sanction and start installing. “Once the ESCO agreement is finalised, the customer feels we are wasting our time in subsidies. They want to execute the project at the earliest.” There are still confusions for subsidies relating to an ESCO model. Who should receive the money? The owner of the technology, or the owner of the land on which the sunlight falls?

As a child, Srinivasan moved all around India with his father, who worked for the country’s leading large-scale power companies of both public and private sectors. Did he ever think of following in his footsteps? “No,” he says, without a second’s thought. You can see his sharp business mind has already dismissed the idea. “Coal doesn’t interest me. And anyway, it is not the future.

“Renewable energy is the future.”

Fact Box

Supplying energy services

Details of the energy services contract between Trans Solar Technologies and Holy Family Hospital

CUSTOMER PERSPECTIVE	
Hospital requirement:	22,000 litres of hot water (minimum of 60 degrees Celsius) per day.
Earlier solution:	Investment in a gas boiler. Bill for operations Rs. 60,000 to Rs. 90,000 per month.
New solution:	Seven-year contract with Trans Solar Technologies to deliver hot water. TST is acting as an Energy Service Company, or ESCO.
Contract details:	Hospital provides TST with water, free of charge (as provided by the State), Hospital pays TST Rs. 55,000 per month to heat this water, for 7 year period, In return, TST provides hospital with 22,000 litres/day at 60 degrees Celsius or above, TST installs its own solar thermal hot water system on 200m^2 of hospital roof to do this, If water is less than 60 degrees Celsuis, TST pays for gas to do the remainder of heating in a gas boiler.
ESCO PERSPECTIVE	
Equipment:	Solar thermal flat plate collectors. Capacity of 22,000 litres /day.
Investment:	Rs. 1.8 million on solar thermal hot water system.
Source of investment funds:	Private investors.
Operational costs:	Rs. 10,000/month.
Return to investor:	Rs. 37,000/month for 5 years i.e. payback of Rs. 2.2 million over 5 years.
AFTER THE CONTRACT EXPIRES	One of three options exists: 1. TST exits and assets transferred to hospital at a depreciated value. 2. Contract renewed between the two parties with renegotiated tariffs. 3. Contract renewed between two parties with renegotiated tariffs and technology upgrade.
Contact:	S. Srinivasan, Trans Solar Technologies. Mobile +91 9810817592. Email: transsolartechnologies@yahoo.co.in, website www.transsolartechnologies.com.

Features to notice:

- The customer's focus is often on 'energy services,' rather than just energy.
- There is a need for business innovation to absorb technical and financial risk.
- Small-scale systems allow you to know your customer, and tailor solutions to them.

Basic principles of the relationship between an Energy Services Company (ESCO) and a customer

Energy Services Company (ESCO)

- Invests in technology
- Manages, maintains and operates the technology
- Owns the assets
- Delivers the energy service/s (eg. 22,000 litres of hot water/day)

An energy service contract

- Defines the service to be provided (eg. heating of water)
- Defines a period of contract
- Defines a tariff for the service
- Defines service levels and actions for failure

Customer to the ESCO

- Has a need for energy service/s (eg. 22,000 litres of hot water/day)
- Does not understand technology and its operation
- Cannot take risks (eg. technology failing)
- Pays for the energy service on the basis of a tariff

CASE STUDY IX

Image: M. Radharkrishnan and R. Bhuvaneswari, elected members of Odanthurai Panchayat, in front of the Panchayat' s 350kW wind turbine..

Buying into wind power

Odanthurai Panchayat, Tamil Nadu

The population in Odanthurai Panchayat is rising. It has good roads, good schools and good housing, and people want to live there. Providing public services for the growing numbers is a challenge for governance, one felt in many panchayats in India.

It is fortunate, then, that Rangaswamy Shanmugam is an innovative man. As president of Odanthurai from 2001 to 2009, he repeatedly sought unusual solutions to common problems, through renewable energy. Under his leadership, the Panchayat in Karamadai block of Tamil Nadu has resolved issues of lighting, water and waste through this 'non-conventional energy,' as the 55-year-old calls it. His solutions have culminated in a very unconventional purchase for a Panchayat: a 350kW windmill.

It was a financial analysis of Odanthurai's expenditures in 1996 that exposed public electricity as the drain for fifty to sixty per cent of Odanthurai's income. The yearly bill ate all of the Panchayat's tax revenue (Rs. 675,000), and some of the grant they received from the State Government. At present, approximately nine per cent of the state developmental budget of Tamil Nadu is devolved to Panchayats that come under the Department of Rural Development and Panchayat Raj. These funds are intended for development projects such as roads, housing, or water and sanitation. Public electricity, including 575 streetlights, fifteen water distribution pumping motors and one borewell motor, was the single largest expenditure in Odanthurai for which no grants were received. Shanmugam knew it was only set to climb higher: in 1996, a mere 1,500 people lived in Odanthurai's eleven villages. Today, more than 8,000 are packed into its 1,119 square kilometres. All need to be provided with electricity and water.

The President started attending renewable energy trade fairs and training programmes, organised by TEDA[1] as part of their mandate to raise awareness and knowledge of renewable energy. Shanmugam would look up dates of the fairs and take the bus to see what was happening. In the conference halls he'd tour from table to table, quizzing renewable energy companies on the technologies they displayed and what they could do for his panchayat.

"If you're genuinely interested, these things exist," Shanmugam says easily. "You just need to have the drive to go and find them." He is wearing all white, the only colour from a thick gold band on his finger and the red and grey smear of *tilakam*[2] across his forehead. He's from a wealthier background than some, with a relatively good landholding and an education up to tenth standard, but dismisses the idea that these advantages might be requisite for renewable energy initiatives. "It's nothing to do with education," he says. "It's purely passion and a drive to do these things. If others can't, it's a lack of interest."

"When Shanmugam suggests something, we know it's for our benefit," nods M. Radharkrishnan, a Panchayat member and saw mill worker. We're told more than three thousand plans have been executed in the Panchayat under the family's leadership, for Shanmugam's father was President before him, and his wife Lingammal Shanmugam now holds the same position. Not a single one of those plans has been opposed. The Panchayat's hallmark commitment to transparency has resulted in public accounts being painted on the outside walls of their office buildings. From housing projects to Rs. 178 to obtain a death certificate for a deceased man, all public money expenditures are listed for residents to see.

Lights

A renewable energy workshop convinced Shanmugam to install solar streetlights in place of the grid-connected lights in two of Odanthurai's villages in 2001. The cost of twenty-five streetlights came from Panchayat funds, and immediately shaved Rs. 5,000 from their monthly electricity bill. Shortly afterwards, he installed fifteen more, cleverly covering half of the cost of all forty lights through a housing scheme for landless migrants, and drawing the other half

[1]Tamil Nadu Energy Development Agency, the state nodal agency of the Ministry of New and Renewable Energy in Tamil Nadu.
[2]Tamil name for the mark commonly worn on the forehead by followers of Hinduism, symbolising the third eye. *Tikka* in Hindi.

Image: Rangaswamy Shanmugam, ex-President of Odanthurai Panchayat.

Image: A boy drinks water pumped from the public filtration plant. The government building behind him has the Panchayat's accounts painted on it for transparency.

from MNRE[3] scheme grants. Eighty per cent of the Panchayat's inhabitants are landless labourers, many of whom have migrated to its housing projects. A fifth of the population are Irulas, members of a local scheduled tribe[4].

A process was quickly established: Shanmugam specified what he wanted to the District Rural Development Agency (DRDA), and they would help him negotiate the labyrinths of grant schemes and complete the paperwork. The solar streetlights still operate today, and their installation has been sewn in to all future housing projects in Odanthurai.

For Tamilselvi, 35, the streetlights have more than a financial value. She lives in one of the housing areas not yet reconstructed, in a hut made of dried coconut fronds. The only electric light here is from the solar streetlights. "We're living in darkness, and it's difficult for the children to study," she says. She says the family uses kerosene inside the house, and it occurs to us how flammable its construction material must be. Until they get their new house, her children study under the solar streetlight outside, which spills its circle of white light onto the road from 6pm to 6am every night.

Water

In 2003, Odanthurai's water supply came from river to tank to tap, with no treatment in between. Failing to separate the supply used for drinking and non-drinking purposes had created vicious cycles of water-borne diseases. There was an urgent need to address the problem.

A village water and sanitation committee was formed. Their solution was to treat the river water for drinking supplies, by building a plant to sanitise the amount of potable water required. This separated the two classes of water in the Panchayat. For non-drinking purposes - cleaning and toilets – the villagers could fill their pots from mini water cisterns at various public points across Odanthurai, stocked with groundwater pumped from borewells. For drinking water, the Panchayat invested Rs. 4.8 million in a 7kW pump to bring water from the River Bhavani, after which it was passed through sand and ceramic filters. Following chemical treatment for bacteria, the safe drinking water was pumped to houses in nine of Odanthurai's eleven villages through an existing underground pipe network. Ninety per

[3]Ministry of New and Renewable Energy

[4]'Scheduled Tribe' is a grouping of tribal communities as defined by the Constitution of India. Traits include traditional occupation of a definite geographical area, distinctive culture featuring tribal ways of life, primitive characteristics of occupational patter and economy, and lack of education and techno-economic development.

Image: Children study under a solar streetlight in one of the few remaining areas without domestic electricity in Odanthurai Panchayat.

cent of the costs of the treatment system were sourced from the Rajiv Gandhi Drinking Water Mission, a central government scheme to improve health; the remaining ten per cent came from the public.

"We did two surveys of water borne diseases in Odanthurai," says Shanmugam. "One before the treatment system was installed, and one after. In the one after, the rate of water-related diseases had dropped to zero."

The system was crucial for the residents, but came with high electrical running costs. However, the Panchayat was becoming adept at leveraging government schemes to their advantage. To bring down the cost of pumping and distributing 275,000 litres of water per day, the Panchayat installed a 15kVA biomass gasifier plant[5] next to the river. The cost was Rs. 310,000, of which Rs. 135,000 came from an MNRE subsidy, and the remainder of funds from the Panchayat.

"The most important part of this is that I get water with zero bacteria in it," says R. Bhuvaneswari, a mother of four. She's ward councillor of her village, Vino Bhavji Nagar, which receives both free grid electricity to each of its 135 houses, and free clean water from the pump. She's also a Panchayat member. "I used to have to go three kilometres for a pot of water," she continues. "Now, it comes right to the village. The neat layout of brightly-coloured houses was one of the first housing projects built by the Panchayat, and has had solar streetlights for six years. "We're able to move around in the dark without fear of insects. We can tell you that snakebites have reduced. Through all these schemes – proper housing, water and lighting – ninety per cent of our problems are reduced. We're pretty happy."

The biomass gasifier, fed with wood[6], covered all the electricity requirements of the water treatment system for five years, and saved the Panchayat sixty-five per cent on bills to run the water treatment plant. In 2008, its use was discontinued, as it no longer made financial sense: the cost of wood had increased significantly. The biomass gasifier also had increasing labour costs, which were expensive for the Panchayat as they weren't supported by government. The electricity from the grid didn't require local labour. The

[5]See diagram, page 109.

[6]See addendum on use of biomass as fuel, page 111.

Image: Children play in one of the newly constructed housing blocks in Odanthurai Panchayat, Tamil Nadu. Partly because of its good roads, good schools and good housing, the population in Odanthurai is rising fast, and the governing body have turned to renewable energy to lower their public electricity costs.

grid in Tamil Nadu was reliable, unlike that of other states, and the daily two-hour powercut announced in advance through the newspapers. The biomass gasifier therefore stands unused and is now a sunk investment. While the Panchayat was proactive in cutting operating costs of the water treatment plant, it failed to foresee the increase in biomass costs.

Waste

Vino Bhavji Nagar was also the site of a more unusual experiment in renewable energy in 2002: a community biogas plant based on nightsoil. Nightsoil-based biogas works in the same way as any biogas unit[7], except that the feed material is human waste. A large underground dome was built in the village, fed by pipes from thirty-five toilets. Tubes at the top of the chamber carried gas to the kitchens of fifteen houses, where the methane content was burnt in a gas stove. Human faeces decomposes in anaerobic conditions to have some of the highest methane content of any common biogas feed – more than cow dung, and similar to grass – and the system has no smell if managed properly. Technically, it's brilliant: sanitation and pollution-free cooking achieved through one solution. Socially, it's almost impossible, as people don't like the idea of cooking with gas made of excrement. It's widely acknowledged that this plant in Vino Bhavji Nagar was abandoned after two years, and most of the women in the village claim the gas isn't used. One or two attest that it is, but that nobody wants to admit it.

Wind

Shanmugam's experiments in small decentralised energy projects had given him a good understanding of the possibilities and risks they could bring. Now his sights moved to bigger and less risky solutions.

"As the population grew, we realised we needed a lot of power to cater to everyone," he says. "Wind would be the only way to go." Odanthurai is close to the wind farm belts of Tamil Nadu, and general awareness of wind power is relatively high in the area.

Shanmugam formed a committee of Panchayat members and advisors from government development bodies[8] to give advice and technical assessments of companies dealing in wind energy. "Sunlight and air are free, so it's the most intelligent way to produce energy," he points out. "Producing electricity from materials that will run out doesn't seem very sensible."

The Panchayat first thought to commission a hybrid electricity system that would tap solar energy during the day, and wind energy at night, but the government scheme that would have funded ninety per cent of it closed at the last moment. Instead, they selected Suzlon, a leading global wind power company, and a 350kW wind turbine.

Odanthurai did not install a wind turbine in the Panchayat. Instead, in 2006 they purchased a turbine in a wind farm called Maivadi, 140km away from their land. This is a rare action from a public body – all the other windmills in Maivadi are owned by commercial enterprises. The wind farm belts of Tamil Nadu spread across this area, and the turbines stand in giant grids, white blades sweeping through the air. Each windmill creates electricity from the power of moving wind and feeds it into the electricity grid. Whoever owns the turbine owns the electricity, and is paid by the State Electricity Board in return for adding to the grid.

It cost Rs. 15.5 million to purchase the wind turbine – a major investment for a Panchayat. With Rs. 4 million of saved funds, the committee leveraged a seven-year commercial loan for the remainder of the money with the Central Bank of India in Coimbatore, Avarampalyam Branch, at a rate of eight and a half per cent. They decided that, until the loan was repaid, all money generated by the windmill would go to the bank. That was four years ago. For the next three years, Odanthurai's electricity scenario will continue almost as if they didn't have the windmill, by paying the electricity board Rs. 3 per unit for their 22,000-unit monthly electricity requirements. In 2013, the sweeping turbine blades and the land on which the windmill stands will be theirs. Turbine number G827 – the turbine owned by Odanthurai – produces around 675,000 units of electricity a year. Shanmugam estimates the Panchayat's electricity requirements will be 450,000 units by 2013. The windmill will generate 225,000 units in addition to that, which the board will purchase from the Panchayat at Rs. 2.90 each. Odanthurai will then not only have no electricity bills to pay, but also an income close to Rs. 800,000 per year.

"[Shanmugam] has a very sharp commercial brain," observes Vinoth Rangaswamy, a friend and nearby resident. "He's aware that, if a small section of every scheme can be used for commercial purposes, some money can be made which can go towards the next scheme."

Shanmugam's already thinking of the next plan: invest to make the Panchayat's domestic electricity load independent of the electricity board, too. That way the household lighting and fans of future immigrant populations could be taken care of. "It's not good to depend on someone else for electricity," he considers. "It's much better that we make our own."

[7]See diagram, page 29.
[8]District Rural Development Agency, District Collectorate, Tamil Nadu Energy Development Agency

Fact Box

Wind power for Odanthurai Panchayat

Who:	Odanthurai Panchayat, Coimbatore District, Tamil Nadu. President from 2001-2009: Rangaswamy Shanmugam. Current President Lingammal Shanmugam.
What:	Panchayat as independent power producer, through purchase of 350kW wind turbine. Turbine located in Maivadi, a Suzlon wind farm in Tamil Nadu 140km from Odanthurai. All turbines feed into the electricity grid.
When:	Wind turbine purchased in 2006.
Financing:	Cost of Rs. 15.5 million, Rs. 4 million direct funds from Panchayat savings, remainder through a seven-year commercial loan from Central Bank of India, Avarampalyam Branch, Coimbatore, at 8.5% interest.
Electricity generated:	675,000 units/year, sold to grid at Rs. 2.90/unit
Panchayat earnings:	2006-2013: All proceeds from sale of units go directly to bank for repayment of loan. 2013 onwards: net metering arrangement with Tamil Nadu Electricity Board. Panchayat's electricity consumption anticipated to be 450,000 units/year. Surplus of 225,000 units/year will generate revenue at Rs. 2.90 per unit, a total of Rs. 798,000/year.
Contact:	Odanthurai Panchayat, Karamadai Panchayat Union, Coimbatore. Email odenthuraipanchayat@sanchamet.in.

Features to notice:

- All renewable energy projects in Odanthurai are driven by their financial viability.
- Panchayats can be proactive and play a key role in deployment of renewable energy.
- Unfortunately, Odanthurai is not the norm. There is a need for knowledge surrounding renewable energy and financing schemes to reach out to local governing bodies.

CASE STUDY X

Image: A biomass gasifier, owned and operated by Husk Power Systems Pvt. Ltd. Husk Power Systems uses biomass gasification to generate electricity from discarded rice husk, and provides electricity to over 100,000 people across more than 125 villages in Bihar.

Electricity from rice husk

Husk Power Systems, Bihar

"When you travel through Bihar at night," says Ratnesh Kumar, co-founder of Husk Power Systems, "every place you see is dark. You don't see anything."

"But if you travel during the day, no matter where you go you'll find roads full of people in the remotest of places. Houses just next to the highway." His voice is slow and steady, like his manner. "But people won't light their lanterns for a moment longer than they need, as they are so poor."

In such lean conditions as in Bihar's villages, people waste very little. When Ratnesh and Gyanesh Pandey, Ratnesh's childhood friend and the other co-founder of Husk Power Systems, first began to research the living conditions in these villages, they found that even the garbage gathered in the evenings was used in some way. "Villagers live in complete harmony with nature," explains Ratnesh. In these stretches of darkened countryside, they found only one substance that was going to waste: the leftover husk of rice grains. Ratnesh and Gyanesh decided to use this one stray link to produce what the villagers most needed.

Their company, Husk Power Systems, now provides electricity for six to seven hours each evening, to about 100,000 people across 125 villages[1], using only rice husk.

The power plants that have achieved this impressive task are modest in appearance. A typical Husk Power Systems (HPS) compound is only 5000-6000 square foot of rented land with a small biomass gasifier on it (see diagram, page 109), one storey tall and slim enough that two men could encircle it with their arms. There are large piles of biscuit-coloured rice husk for feeding the machine, and smaller piles of black rice husk char, which is the small amount of solid waste the gasification process generates in addition to the gas. Next to the gasifier are four filters for cleaning tar and dust from the gas, and a generator in which the gas is used to fuel an internal combustion engine and generate electricity. From the compound run the HPS wires that carry electricity to houses: a local distribution grid. Grids reach a maximum distance of two to three kilometres, because, beyond that, there begins to be a drop in voltage. To further increase efficiency, the company also insists that customers may use only CFL bulbs.

HPS focuses its attention primarily on villages that are off-grid, but will set up anywhere there is rice husk and a demand for electricity. As of September 2010[2], they had thirty-five power plants in operation; four of 52kW and the rest 32kW installed capacity. Once the twenty-five plants currently under installation are complete, HPS will have a total installed capacity of about 2MW.

HPS pays under one rupee per kilogram for rice husk, and by loading fifty kilograms per hour into one of their 32kW power plants, can produce enough power to sustain a load of 700 typical rural households at the same time. The model seems unstoppable: this year, Bihar will produce 1.8 billion kilograms of rice husk. If you extend the model to all of India, as HPS plan to do, they say it is possible to generate 27GW of power from just the waste rice husk that is produced in the country[3]. That's one sixth of the total installed generating capacity of the country.

Part of the beauty of the model is that it's built on a resource that costs, as Ratnesh describes it, "not that much." When HPS first began buying rice husk for their pilot plant, local millers noticed the commodity had become valuable and started hoarding it, driving prices up accordingly. Ratnesh and Gyanesh responded by setting up their own rice mill, dehusking villagers' rice for free. All the other rice mills went out of business. Ratnesh and Gyanesh signed a contract with them, guaranteeing that they could buy rice husk at an affordable price for the next six to eight years, and then shut down their free mill to direct the business back to the other mills. They have a similarly inclusive approach to the diesel merchants, as many of the villages they've set up in have private micro-grids already in place. "First we offer [the diesel merchants] work at our plant. If they choose not to work with us, there's enough business that we can both set up there. We don't want to completely take over somebody else's business." Ratnesh laughs a little. "We do take some share of their market, though."

[1]These figures are constantly increasing. See www.huskpowersystems.com for recent figures.
[2]See www.huskpowersystems.com for recent statistics.
[3]See addendum on use of biomass as fuel, page 111.

Image: Portrait of Ratnesh Kumar, co-founder and COO of Husk Power Systems. An 8kVA biomass gasifier plant owned and operated by Husk Power Systems is seen in the background.

Image: Ratnesh Kumar discusses operations in front of Husk Power Systems plants.

Sariswa: a village lit up

Sariswa village in West Champaran district is one of the villages receiving electricity from HPS, via a 32kW biomass gasifier power plant situated on its outskirts. Sariswa is also connected to the state utility's grid, but it rarely provides electricity to them. In contrast, the HPS plant now provides electricity to around 230 customers, spread over domestic and commercial use, lighting lights and whirring fans. Almost everyone with a connection now has a television in their home, and all customers pay their electricity bills in advance.

For a customer, the HPS electricity is an excellent deal. Anush Kumar, 25, runs a hostel for the village schoolboys in Sariswa. He previously paid Rs. 1,700 per month to run a diesel generator to light the hostel from 6pm to 9pm, but now pays Rs. 1,200 a month to HPS for a power supply from 6pm to 1am from their nearby plant. The students can study later, and a saving of Rs. 500 can really make a difference when you have 125 boys to take care of. "I'd be happy to pay for full, twenty-four-hour access," he says. "We have a grid connection but it only gives us power for one or two days a month. It's useless."

Villagers say that burglaries have reduced because of better lighting at night, and the number of snakebites in each village suddenly dropped to zero when the electricity came. Quality of life for women improves as they can at least see the insects that swarm as they're cooking, and shopkeepers make more money, as they can stay open for more hours. A 30W connection (two 15W CFLs) costs Rs. 80-100 a month, and most plants operate for six to seven hours every evening. "They wouldn't have got a better deal than this in their whole life," says Ratnesh. Initially customers were billed after using the electricity, but there were problems when some people refused to pay, so a local employee now collects the fees ahead of delivery.

Madi Devi, 50, sits in the marketplace down the street with a two-year-old child asleep in her lap. The 32kW Sariswa plant is already operating at full capacity, and so Madi has not been able to take a connection. She'd like to, and says she would pay for it. The HPS connection would be cheaper than the kerosene she buys at the moment, and her household could save Rs. 150 per month. What would they spend it on? "Food," she says simply. The family of seven have a monthly income of Rs.1500.

The dim tarry light from Madi's kerosene lamp is one of three grades of light in Sariswa village at nighttime. Those doorways with a connection are pooled in the white light of a CFL bulb, and above each connected household hang a bunch of low wattage yellow bulbs like balloons. These

Image: Shops in the Sariswa village market use power generated by the Husk Power Systems.

filament bulbs are HPS's field method of monitoring consumption: a customer can have as much electricity as they want and would want to pay for, but there has been a problem with people stealing by using more than agreed. The filament bulbs work as fuses because they burn out when too much electricity is drawn.

Delivering energy: the social challenge

Ratnesh blames the theft on rural Bihar's "inertia to change," and a sense of entitlement borne of an intractable caste system. He tells a story of one village, where an HPS electrician fitting a fuse outside an upper-caste man's house had a gun held to his head by the furious customer, who felt his caste gave him the right to free electricity. When the electrician did not desist, the man "broke his head" with a stick. A police complaint went nowhere. "This man would spend Rs. 50,000 fighting the case, but he wouldn't pay Rs. 80 a month because he had to show his supremacy in the village," explains Ratnesh. In the face of such brutality, HPS shut the plant and 500 villagers lost their electricity connection. "The whole village suffered, but no one came forward to say anything." Ratnesh shakes his head.

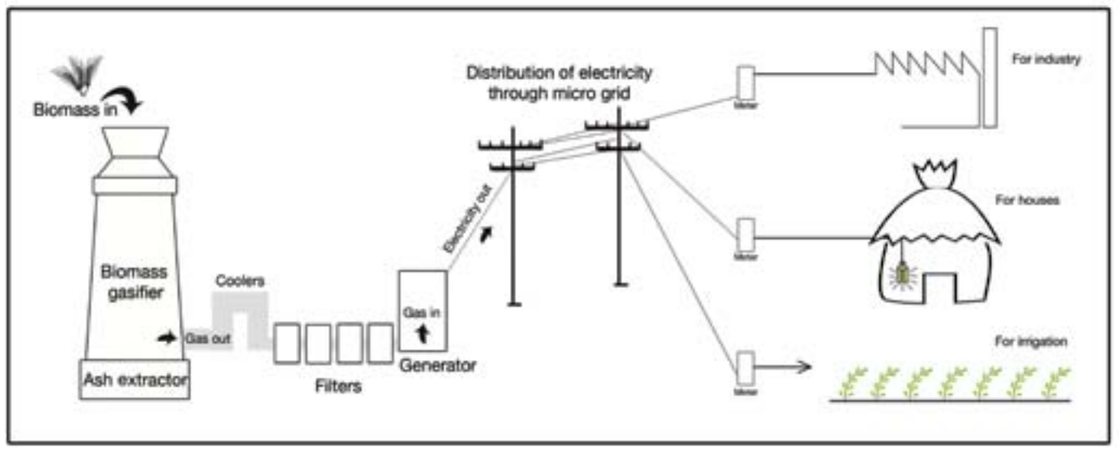
The stubborn caste system is something that HPS is striving to challenge through their power as an employer as well as a supplier. On one of the days we visit, Ratnesh has driven the eight hours from Patna to play a game of football with the HPS employees of West Champaran District. The managers play next to the husk-loaders in the pouring rain, distinguished only by their shirt or lack of it to demark the two teams. HPS insists that all employees refer to each other respectfully, with the *ji* suffix to every name, but creating a sense of equality is a slow process.

"Sir! Sir! Shall I kick the goal now, sir!" shouts one employee to his managers, pausing in front of the makeshift goalposts. "Just kick it!" They shout back.

From darkness to light: a growing business

The exemplary HPS model has won accolades, both social and financial. Yet if they hadn't won their first monetary awards in the US, accessing start-up finance could have posed a problem, and banks do not consider such projects in Bihar a worthwhile investment. Yet HPS now has thousands of paying customers in both domestic and commercial sectors across Bihar, and have just built their first plant in Uttar Pradesh. There are plans to expand to Tamil Nadu, West Bengal and Assam, as well as across the border to Nepal. "Anywhere there is rice husk, it can work," says Ratnesh. They've now discovered that silicon can be extracted from the rice husk char, and plan to start selling this to solar panel manufacturers, creating in-house

Image: Madi Devi, 56, sells alcohol for a living. Her family of seven has a monthly income of Rs. 1,500, of which she spends Rs. 150 per month on kerosene for lighting.



A generic model of electricity generation and distribution by biomass gasification

employment for rural women in Bihar in the process. They're also seriously contemplating registering HPS's power plants under the Clean Development Mechanism (CDM)[4], which would bring them an extra income of around Rs. 100,000 per plant per annum, based on the calculation that an electricity connection will save a villager from burning ten litres of kerosene per month.

They have no interest in patenting their model. The secret lies not in the biomass gasification system, which is "so simple that even a person who cannot read and write can operate it with a little bit of training," sniffs Ratnesh, but in their social blueprint. Most of the managerial staff trained at India's best business schools, and have left jobs with higher salaries both at home and abroad to work long hours in villages with no connectivity and no toilets. "But they work very well," says Ratnesh, "because they also want to make a difference." Some other employees previously led lives of drugs or crime, and now work for HPS on the straight and narrow. The unifying factor is "passion," thinks the co-founder. "If you don't have that, you can't work with us."

One suspects there must be some negative externalities to the model. Every method of power generation has them. "To be honest," Ratnesh says, "of this plant, I haven't seen any. We have analysed noise level pollution, quality of gas, the effect the plant is having on the surrounding area…" The positive effects witnessed in Sariswa are found across the villages in which HPS has set up plants. On the final day we meet, he shares some news. It's a small piece of news, but it holds a wonderful potential. Five residents from the village where the upper caste man beat an electrician, and HPS had to shut their plant, came to see Ratnesh in the morning. They told him they wanted electricity, and were prepared to put in the work to start up a plant themselves. HPS decided that these five villagers will be their first production franchisees.

When Ratnesh and Gyanesh were children, they used to chant a *shloka* in the mornings at school. *Aum*, the children said.

Asato ma sad gamaya,
tamaso ma jyotir gamaya,
mrityor ma aamritaam gamaya

Line for line, it means

Lead me from ignorance to truth,
from darkness to light,
from death to immortality.

Today, *tamaso ma jyotir gamaya* – 'from darkness to light' - is the motto of Husk Power Systems.

Note: This case study was first printed in 'Empowering Bihar,' released by the Greenpeace India Society in October 2010

[4]For more details on CDM, see http://cdm.unfccc.int, and addendum on page 111.

Fact Box

Husk Power Systems

Type of technology:	Biomass gasification
Source of energy:	Rice husk. Fifty kg of rice husk an hour can run a 32kW plant. This year, Bihar will produce 1.8 billion kg of rice husk – which could produce about 2.2GW of power. See addendum on use of biomass as fuel (page 111).
Supply chain:	Husk purchased from local rice mills at less than Re. 1/kg, without seasonal variation. One month's stock of husk is stockpiled during the monsoon to ensure dry feed is available.
Plant details:	Thirty five in operation, and 25 under installation. Most plants are 32kW installed capacity; four are 52kW. Once all 60 plants are completed, total installed capacity will be about 2MW.
Funding:	Initial investments were from personal funds. Since, HPS has received funding from the Shell Foundation, International Finance Corporation and other funding bodies. The company also receives Rs. 15,000 per kW of the system as capital subsidy from the MNRE.
Investment:	Total installation costs are less than Rs. 50/watt, including distribution. Running costs are Rs. 20-22,000, including salaries, husk cost, maintenance cost.
Return time:	About 2-3 months to become operationally profitable, and 2-3 years for capital expenditure to be returned, depending on whether subsidies are received, and how much they amount to.
End users:	Eleven to twelve thousand connections have been taken across over 125 villages, of which 80-90% are domestic users. In all, more than 100,00 people benefit from HPS electricity.
Billing & payment:	Domestic users pay Rs. 80-100 per month for a 30W connection (two 15W CFLS). Electricity is available for six to seven hours in the evening in most plants. Payment is monthly, collected in advance by a local HPS employee.
Employment created:	Each plant employs around four people
Contact:	Ratnesh Yadav, Co-founder, Husk Power Systems. Mobile: +91 8986181808. Email: yadav@huskpowersystems.com

Features to notice:

- Reliable energy services are linked to local economic development.
- The financial viability of the systems stems from their local emphasis.
- Business plugs into a local supply chain – in this case, rice dehusking – without polluting the local environment.
- Customer segment that is largely perceived to be unwilling or unable to pay for electricity is both willing and able, if the service is good.

Addendum

Use of biomass as a fuel

The case study on page 101 describes a decentralised model of electrification using biomass gasification technology, with “agri-waste” as feedstock. Biomass gasification is also mentioned in the case study on page 91. It should be noted that there are some concerns over the use of biomass as a fuel. These are:

- Conversion of food crop into fuel
- Conversion of land under food crops to fuel crop cultivation
- Conversion of agricultural waste into fuel as opposed to being converted into ecological soil nutrients
- The definition of ‘wasteland’ in India, and the danger that it may be used sweepingly and inaccurately to describe areas with both ecosystem functions and socioeconomic relevance.

All of these issues are critical considerations for sustainable agriculture and food security. To clarify, there must be no sacrifice of food for fuel. Greenpeace does not present the case study of Husk Power Systems to particularly advocate the model of biomass gasification, or a blind scaling of this model regardless of which resources are available locally: to do so would be to contradict the very essence of the decentralised model.

There is much valuable information to be gleaned from these case studies, but their most important lesson is that decentralised power generation from renewable energy must be highly localised in both its design and implementation, with detailed assessment of, and sensitivity to, both local requirements and local resources. Policies relating to this type of renewable energy must strive for local and regional understanding of resources, considering energy as a route for resource development, rather than a provision that is in conflict with resources.

The Clean Development Mechanism

The case study on page 21 features the clean development mechanism (CDM) as a source of funds for construction of biogas units. While Greenpeace supports this project and the use of biogas as a form of renewable energy, it should be noted that Greenpeace does not promote the use of the CDM for financing renewable energy. We believe the prevailing CDM regime needs substantial reforms to ensure that the highest levels of environmental integrity are applied to every CDM project, and that emissions avoided through the mechanism are not double counted. Greenpeace is also of the view that any kind of offset mechanism should not used for no-regret cost mitigation options.

Image: A community of Musahars - the poorest of the poor caste in Bihar - who have never had an electricity connection. Decentralised renewable energy could provide communities such as these with vital, reliable energy services, free of the urban preference of the centralised electricity grid. Sikandarpur Village, Danapur, Bihar.