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CASE STUDIES FOR BRIDGING THE ENERGY DEFICIT AND DRIVING CHANGE

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Cover image: An electrician at Tripolia Hospital, Patna, operates the concentrated solar power (CSP) system on the hospital roof. Tripolia's CSP systems create steam to sterilise all of the hospital's medical instruments, dressings, bedsheets and laundry, using the free and renewable energy of the sun.

Photography: Harikrishna Katragadda

Printed on 100% recycled paper

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.

Introduction

Bihar is India's third most populated state, and more than half the people live below the poverty line. For many years the state has been immobilised by an obdurate caste system and linked political corruption, and many have little or no access to that essential provision: a consistent energy service.

The bifurcation of Bihar in 2000 partitioned most mineral deposits and large-scale power stations into the daughter state of Jharkhand, and the energy deficit in Bihar is now one of the most severe of any state. Access to reliable energy services – needed for everything from refrigerating medicines to powering machines - is closely linked to both social and economic development, and Bihar's progress will be impeded unless a way can be found to provide reliable, affordable energy services to the people at the earliest opportunity.

In the current, centralised electricity provision scenario, the rural population are the last to receive energy services. It seems there is a clear urban/rural divide[1] in electricity provision. Even in those places where the grid has been extended to villages, the rural poor rarely, if ever, receive reliable energy services. This patchy access to power for such a large section of India's population is a clear case of energy injustice, and one that looks unlikely to change even with the centralised addition of installed generating capacity.

Yet Bihar has the option of drawing energy from local, renewable, sources. The state must begin to tap this potential, and do so in a way that delivers energy justice to its people.

Decentralised renewable energy

Renewable energy can easily be harnessed on a small scale, at or near the place where that energy is needed. This 'decentralised' approach to energy production means that a system can be designed according to what resources are locally available, and what the local demand is. With intelligent design that appraises both of these at a local level, and a commitment to use resources in a sustainable manner, decentralised renewable energy systems can stimulate the local economy. Systems can focus on delivering the energy services needed by people in that area, which can change with location, as opposed to just supplying energy. They can also be empowering, providing the opportunity for people to operate and govern their own energy services, ensuring they are not disadvantaged by the urban and industry bias that currently dominates the centralised system.

Decentralised renewable energy also makes sense because less energy is wasted, as electricity is not transported over long distances between the place it is generated and the place it is used. Unlike large-scale energy production, the infrastructure of small-scale, decentralised systems can be set up to begin delivering energy in a matter of weeks.

The forms these systems can take are diverse, depending on what is most suitable to the demand and location. Systems can produce electricity, as in the first case study included here, or provide other energy services, such as in the second story. For those systems that produce electricity, the decentralised system can be stand alone, in which all energy harnessing and distribution takes place within one isolated mini-grid, or grid-connected, in which the system interacts with the main electricity grid, feeding electricity into it and perhaps drawing it out when required. A system could also use a combination of different types of renewable energy: solar photovoltaic, for example, combined with micro-hydro, would produce electricity from sunlight and from moving water.

[1]See STILL WAITING - A report on energy injustice, Greenpeace India Society, October 2009
http://www.greenpeace.org/india/press/reports/stillwaiting

Decentralised renewable energy works

'Empowering Bihar' contains two very different examples of decentralised renewable energy (DRE) systems successfully providing energy services to people in Bihar.

The first is the story of Husk Power Systems (HPS, page 06), a successful business model with a socially sensitive approach that provides electricity to around one lakh people across 125 villages, using only rice husk. Energy is extracted from this low-value waste through the process of biomass gasification (see page 10). Customers pay in advance for electricity to power lights or fans – interestingly, tariffs are set by the energy service provided, rather than the amount of electricity itself - and the cost is less than they might have previously paid for diesel or kerosene. "We have illuminated thousands of houses," says Ratnesh Kumar, co-founder of Husk Power Systems. "And we have shown that it can be done using only local resources."

Image: Rice husk is used to feed the reactor at the 8kVA power plant, owned and operated by Husk Power Systems Pvt. Ltd.

Image: Medical instruments in Tripolia Hospital are sterilised with steam generated by solar energy.

The second story is of Tripolia Social Service Hospital, a private charitable hospital in Patna that uses solar energy to sterilise medical equipment, sanitise the hospital's laundry, heat water for baths and medicines, light outdoor pathways at night and power a residential building and office. The approach angle of this story is different, however, as economic viability is not their main motivation. "We are saving energy," says Sister Christie, administrator of the hospital. "A lot of energy is wasted in the atmosphere." All the hospital's systems have been designed by and sourced from SAAP, a Christian solar research centre that considers their work as a Ministry. "We don't look into profit and loss like a business, but into how much good it will do people. That is the first question we ask," says Father Paul, SAAP director. "

Improving
people's lives

DRE can have a positive impact on both social and economic aspects of society. In these stories we read that HPS customers have noticed a reduction in burglaries due to better lighting at night, and a dramatic reduction in the number of snakebites for the same reason. Women no longer have to cook in dark or dim light, and the company is now planning to create employment for them extracting silicon from rice husk char; work which can be done at home and so is less likely to conflict with the rigid gender roles of rural Bihar.

The systems can save users money directly. A typical poor family purchasing HPS electricity rather than kerosene will save around one third of their previous costs; money which can be spent on food. Shops can stay open later and generate more revenue. While Tripolia's initial costs on their solar systems were high, they now appreciate having lower maintenance and running costs than they did previously.

A consequence of a business using local resources is that the local economy can also be stimulated. HPS purchases rice husk from local mills, and employs around four people at each of their small plants. Thirty-five plants are currently in operation, and 25 under installation. Their next move is to franchise their production process, which will create further employment and opportunities for local people.

It's not all been smooth sailing. There are undeniable social hurdles in Bihar, and it seems models must adapt to these to be successful. There have been cases of violence against HPS employees by customers enraged at a challenge to their caste superiority, that the company has had to work round. Theft of electricity, through both tapping of lines and refusal to pay, has also repeatedly been a problem. Yet in both stories we see entrepreneurs committed to making their models beneficial for society: when HPS first started purchasing rice husk, millers raised the price of the commodity. HPS opened their own mill, dehusking villagers' rice for free, until the millers agreed to sell the husk at a reasonable price. HPS then shut down their own plant to direct custom back to the local millers. With similar concern to benefit local people, both SAAP and Tripolia Hospital are keen to take part in research and experimentation in renewable energy technology to prevent pollution and a waste of energy.

Policy must now begin to recognise the potential, and potential impact, of such DRE systems, and to allow them to become the norm rather than the exception.

Image: Lack of electricity supply forces children to use kerosene lamps and lanterns for studying. Tahirpur Village, Saran district, Bihar.

The way forward

Decentralised renewable energy has the potential to deliver reliable, quality energy services to people in Bihar. Greenpeace believes that deployment of DRE is essential for Bihar's sustainable development, and that policy must be developed to facilitate and support these projects. Civil society organisations must recognise such energy services as a critical right of the people, and join in demanding decentralised renewable energy to facilitate this.

The way forward is a million small energy revolutions.

CASE STUDY ONE

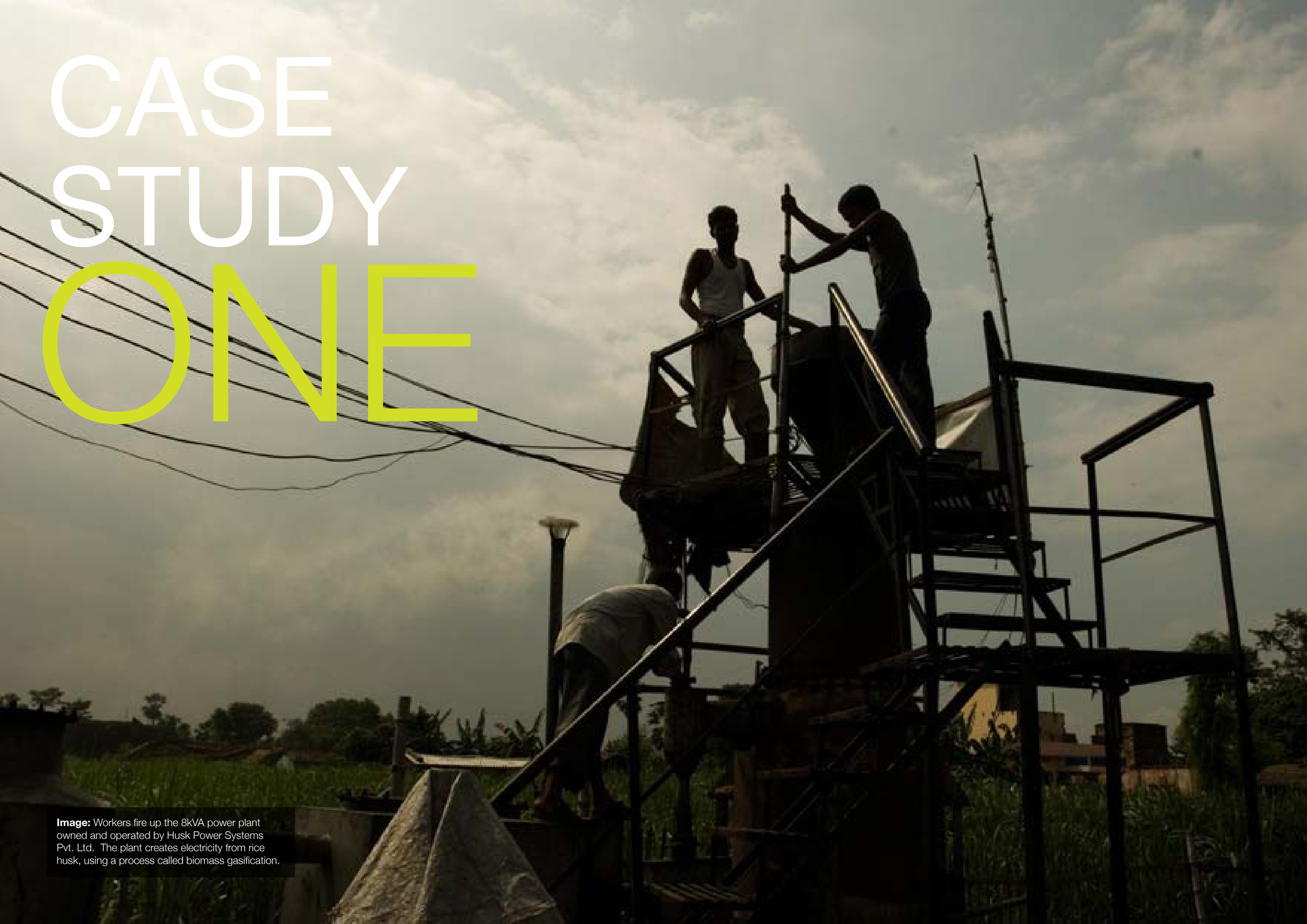


Image: Workers fire up the 8kVA power plant owned and operated by Husk Power Systems Pvt. Ltd. The plant creates electricity from rice husk, using a process called biomass gasification.

ONE

HUSK POWER SYSTEMS

Electricity from rice husk

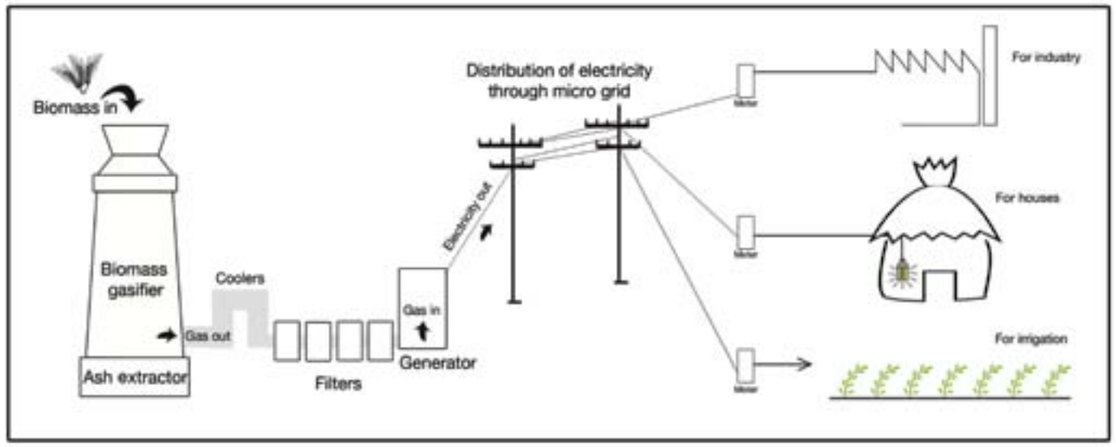
“When you travel through Bihar at night,” says Ratnesh Kumar, co-founder of Husk Power Systems, “every place you see is dark. You don’t see anything”.

“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 1 lakh people across 125 villages, using only rice husk.

Image: Portrait of Ratnesh Kumar, co-founder and COO of Husk Power Systems Pvt Ltd. An 8kVA power plant, owned and operated by Husk Power Systems (HPS), is seen in the background.



A generic model of electricity generation and distribution by biomass gasification

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), 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 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. To date, they have 35 power plants in operation; four of 52kW and the rest 32kW installed capacity. Once the 25 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 50kg 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 180 crore (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 . That's one sixth of the total installed generating capacity of the country[1].

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]See Addendum on use of biomass as fuel, pg 36

Image: Shops in Sariswa village use electricity from Husk Power Systems Pvt. Ltd., generated from rice husk.

Sariswa:
a village lit up

Sariswa village in Bettiah 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. 1700 per month to run a diesel generator to light the hostel from 6 to 9pm, but now pays Rs. 1200 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, 24-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 night time. 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 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.

Image: Madi Devi, 56, sells alcohol for a living. Her family of seven has a monthly income of Rs. 1500, of which she spends Rs. 150 per month on kerosene for lighting.

Image: Shops in the Sariswa Village market use power generated by the Husk Power systems Pvt Ltd.

Delivering energy:
the social challenge

Ratnesh blames the electricity theft on rural Bihar's "inertia to change", and a sense of entitlement borne of an intractable caste system. He tells us about 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, a process that will generate in-house employment for rural women. The silicon can then be sold to solar panel manufacturers. They're also seriously contemplating registering HPS's power plants under the Clean Development Mechanism (CDM)[2], which would bring them an extra income of around one lakh rupees 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."

[2]For more details on CDM, see http://cdm.unfccc.int

One suspects there must be some negative externalities to the model. Every method of power generation has them. “To be honest,” Ratnesh says, “with 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 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.

Image: Ratnesh Kumar, co-founder and COO of Husk Power Systems Pvt Ltd, discusses plant details with an employee in front of one of their 8kVA power plants.

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

“Asato ma sad
gamaya,
tamaso ma jyotir
gamaya,
mrityor ma amritam
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.

Image: An 8kVA biomass gasification power plant, owned and operated by Husk Power Systems Pvt. Ltd.

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 180 crore kg of rice husk – which could produce about 2.2GW of power. See addendum on use of biomass as fuel (page 36).
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, around one lakh 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

Typical savings for a poor family

Typical monthly income for a poor family in Bihar: Rs. 3000
Typical monthly expenditure on diesel/kerosene: not less than Rs. 125
Typical monthly cost of electricity from HPS: Rs. 80
Typical monthly savings on electricity: about one third

CASE STUDY TWO

Image: Electrician Chanesh Prasad inspects the steam outlet of the rooftop solar systems at Tripolia Hospital, Patna. The hospital has installed simple concentrated solar power (CSP) systems to create steam, with which they sterilise all their medical equipment and laundry.

TWO

TRIPOLIA HOSPITAL AND THE SOLAR RESEARCH CENTRE

The value of reliable energy services

In the soft light of the maternity ward of Tripolia Social Service Hospital, Patna, a newborn baby is writhing slowly on a trolley. His skin is a smooth pink and his feet flex and twist, trying out the new air. The family crowd around to look down at him delightedly, while the new mother lies exhausted on a trolley in the next room, a drip in her arm. Her baby has just been delivered by caesarean section, with instruments sterilised by solar power.

Every morning, at about 8 am, the hospital electrician comes up to the roof of the operation theatre and maternity ward at Tripolia, a space that stood bare until about ten years ago. Now, he dodges underneath the four giant mirrored parabolas (see box, page 35) and sets them to reflect the rising sun, so that the beams are focused onto two points at either end of a large header pipe filled with water. By directing all the sunlight that falls on each $8m^2$ mirror dish to a point, the heat of the sun is transferred to the water in the header pipe, creating steam. Through this concentration, just one square metre of reflective dish surface can generate 500W of power. Each dish can therefore pass up to 4kW of power to the water, and so the pressure of the steam builds rapidly. Powered by a simple solar motor, the dishes track the movement of the sun automatically, while, in the rooms underneath, nurses in turquoise operating gowns load bundles of medical instruments into an autoclave and lock the heavy door. Once the pressure reaches 5 bar, the steam shoots through a pipe and into the autoclave. In 15 minutes, normal instruments are sufficiently sterile. In 30 minutes, the operational instruments are too. They glint in piles on the tabletops like a promise.

Image: Electrician Chanesh Prased takes care of the day-to-day functioning of the solar systems on the roof of Tripolia Hospital. The system seen here provides steam for sterilising medical instruments and laundry.

Image: Solar photovoltaic panels on the roof provide electricity to power lights, fans and computers in the building below. Tripolia Hospital, Patna.

Image: A nurse tends to a newborn baby delivered by Caesarian section in Tripolia Hospital. Both the medical instruments the Caesarian was performed with, and the clothes the baby is wrapped in, are sterilised by the hospital's steam-generating solar system on the roof.

Tripolia is a charitable private hospital run by the Sisters of Mercy of the Holy Cross. Sister Anita Abraham, the Nurse Superintendent, wears a peach sari and a golden cross around her neck, like all the sisters here. The 56-year-old nun came to Bihar from her native Kerala 36 years ago, and supervises 25 Sisters, 70 staff, 50 supporting staff and 70 students.

Apart from the few with families, all workers and up to 250 inpatients live on the hospital campus, and are supported by its infrastructure. It's a lot of work to run a hospital, requiring a lot of electricity, and a lot of hot water. Yet the electricity deficit in Bihar is one of the worst in India, and so the hospital is increasingly relying on its own methods of energy generation.

Along with the instrument sterilisation system, Tripolia also has solar streetlights (see box, page 35) on the campus walkways, some solar indoor lights, five hot water heaters for bathing patients and heating medicines, and a laundry sterilisation system that operates on the same principles as the instrument sterilisation system: four huge parabolas on the roof. Both systems are crucial to the health and wellbeing of the patients and are heavily relied upon by the staff, catering to the needs of the 450 people that can stay on campus. For most of the months of the year, the solar systems create steam for the laundry and sterilisation; but for the monsoon days on which there isn't much sun, the hospital pays for electricity from the main grid to generate the steam. Diesel-powered generators are installed as a back-up, though, as grid electricity is not reliable. The sisters say people regularly block the roads in Patna to protest either their lack of water or electricity, and sometimes the protests prevent the doctors from reaching the hospital.

To gain independence from the vagaries of grid electricity, the hospital is choosing to invest further in renewable energy: one year ago Tripolia built a new solar-powered residential unit. Four computers, an office, and the lights and fans of 14 bedrooms are powered entirely by solar photovoltaic; and the hot water of 14 bathrooms entirely by solar thermal. There seems to be an aim to make the hospital campus self-reliant, robust to any variations in supply from the state-provided systems outside. In addition to their power systems, the campus has a livestock enclosure for rearing goats for food, and their own borewell for water. Sometimes people from nearby come to take water, if their own supply has stopped.

The force behind these developments is the hospital administrator, Sister Christie Thomas. She's tiny and kind, but also extremely focused and evidently a force to be reckoned with. "I am not an engineer," she says a couple of times in the conversation, before launching into a very competent description of the installations and their capacities. It was she who persuaded the hospital committee to install the laundry steam system, the solar lighting, and the solar-powered residence. Her faith in solar came from her previous post in a unelectrified village in Jharkhand, "a jungle area" where the sisters had used solar energy to power lamps and a water pumping system for their clinic. "I knew it would work," she says, "and we have an electricity problem."

The initial cost of the laundry system was Rs. 8 lakh – "too high" – but in spite of that Sister Christie thought it was maintenance free and would save a lot of electricity. Some members of the committee disagreed: it wouldn't work the whole season, they said, and the initial cost was a lot for the charitable hospital. Sister Christie managed to convince both those in doubt, and the impartial. She approached Solar Alternatives and Associated Systems (SAAP), the Jesuit-run, Patna-based solar research centre, and commissioned the system. She estimates that the electricity bills of the hospital are now 40% lower than they were before the solar installations. "At least 40%."

Domesticating the sun's energy:

a philanthropic solar research centre

SAAP was started by Father Matthew, a Jesuit mechanical engineer who began designing solar systems in 1996 out of concern for the environment. He set up a campus in Patna, Bihar, and soon became known to locals as Solar Matthew. Fourteen years later, the campus holds a residential building with two live-in Jesuits; a solar research and development 'laboratory' that would be more accurately described as a warehouse; a solar-powered church; and a yard littered with flowers and huge curved dishes of mirror.

"Before I came here, sometimes I used to think: how mad we are, when this energy is available freely, and we use something else." Father Paul Mariadass squints in the bright sunlight of the campus yard. He took over from Father Matthew as the Director of SAAP in 2010. "Is it because of the convenience [of the grid], or because of our madness?

"But it cannot be because of convenience, as these things" - he gestures towards the sun - "are easily there. So it is a little bit of madness. Maybe." He laughs.

SAAP focuses on concentrating solar power (CSP), a technology rarely used elsewhere in India, building a simplified German design of mirrored parabola to reflect sunlight onto a single focal point. The heat at this point becomes very great, and can then be used directly for cooking, or to create steam from liquid water, as in Tripolia hospital. The energy in the steam can also be used to run a turbine, so creating electricity from sunlight. Father Paul calls it "domesticating the sun's energy." They've also created a solar-powered rickshaw (but only as a prototype, "to show the power of the sun"); solar fruit and vegetable dryers, some of which they have installed in the North-East; and various solar cookers including a fryer, oven and tawa for cooking chapatti. The payback period for a parabolic concentrator is a minimum of seven years, but, as Father Paul points out, in many places in Bihar there is no electricity at all, and so the concept of a payback period is irrelevant.

All the inventions so far are Solar Matthew's, but Father Paul has made his mark by taking on the Patna electricity board.

Image: Fr. Paul Mariadass, director of Solar Alternatives and Associated Programmes (SAAP), and team in SAAP's solar research workshop.

Image: Solar Alternatives and Associated Programmes is a Jesuit-run organisation that provides solar solutions to energy needs, aiming to benefit underprivileged sections of society by providing pollution-free solar systems. St. Mary's compound, Phulwaria Sharif, Patna, Bihar.

Image: Electrician Kosmos Bhakla measures the charging level of a battery bank in Solar Alternatives and Associated Programmes.The batteries are charged with electricity generated by solar photovoltaic panels on the roof. St. Mary's compound, Phulwaria Sharif, Patna, Bihar.

Image: Fitter Damodar Sharma operates a drilling machine in the research lab of Solar Alternatives and Associated Programmes. All machines in the workshop run on electricity generated through solar photovoltaic panels on the workshop roof.

"Not because of the concern for the environment," he points out. He is walking around the laboratory, switching lights and loud machines on and off to demonstrate the power in the circuits. A cutter, a driller, a sander… the workshop is now powered entirely by the solar photovoltaic panels on the roof. The electricity board goes on 'raids' to catch those stealing electricity, and on one such raid assessed the collective potential use of all SAAP's laboratory machines to be 22,000 units per month. Regardless of whether the workshop really uses 22,000 units per month, since then the board has been charging SAAP a corresponding flat monthly charge of Rs. 16,000. But the workshop uses only one or two machines at a time, and the building has "never used more than 400 units, maximum," says Father Paul.

As part proof of this, the 1600W solar system not only meets their present needs, but was producing an excess, and so Father Paul bought a few batteries and wired the system up to the church too. Every morning at 7am he gives mass in the church, lit and cooled by solar-powered lights and fans. On a Sunday, he uses a solar-powered audio system to project his voice to the larger audience. The campus would like to sell their excess to the grid, but no such policy currently exists in Bihar. "So I thought, fine. We will be independent." SAAP filed an affidavit requesting their campus to be disconnected from the electricity grid.

Yet the electricity board seems reluctant to lose his custom. Despite removing all the connecting parts he is legally able to, and requesting the board to remove the meter by the end of the month, Father Paul still receives electricity bills – he assumes someone must be hooking their line – and no one has come to remove the meter. He shows us a letter he has written to the board: 'We now perceive delay as a technique used by your officials to cause us mental agony and financial loss,' it reads. 'Kindly stop harassing us mentally and financially.'

Fuelled by solar energy, and social commitment

Whether SAAP is replicable is arguable. It is not a business, but a consultancy agency that works with people to create tailor-made solutions for their energy needs, levying a charge that just covers their costs. Sometimes they give the apparatus for free, just to promote it. "We consider our work as a Ministry," Father Paul says, sitting in his quiet office in a bright blue aertex shirt. "We don't look into profit and loss like a business, but into how much good it will do people. That is the first question we ask." He tells us about many, many 'wireless villages', where the electricity poles stand empty, but is positive about Bihar's future. "They say New York was worse than Bihar, once upon a time."

But what about Tripolia hospital? If a decent, 24-hour supply of electricity existed in the grid, would Sister Christie still want the use of the solar systems, given their limitations? "I would say yes," she considers.

"We are saving energy in the other sense. The electricity is produced in some way; somewhere they are polluting. There is a lot of energy wasted in the atmosphere. Father Matthew used to tell us that when you put so many solar reflectors, they take all the energy. So we thought maybe it would take a little energy out of the compound and make it cooler, but that didn't happen" She laughs hard, then stops. "But it is good. Installing cost is high, but maintenance cost is low."

The hospital has further needs for solar solutions. In the summer time they have less use for hot water, and Sister Christie wants to turn the energy they're not using into an air conditioning unit, for departments such as the blood bank and critical care wing. "If someone will do that for us, I will be very, very happy. They can take us as a research centre," she offers.

The demand for energy services is there, and the resource – sun energy – is abundant. The systems are not necessarily complicated to operate: Tripolia's electrician manages their systems the majority of the time, and if there's a major problem Sister Christie calls Father Paul and he sends a technician.

Yet these opportunities are not being tapped. "Bihar is not revolutionised in terms of solar," observes Father Paul. "Although we have a lot of solar energy, we use a minimal amount.

"Technology remaining inaccessible for people is no use - it has to be made approachable for them so they can take the power of it. Environment and empowerment go together for us here."

Image: Electrician Chanesh Prasad shuts the door of the autoclave in Tripolia Hospital, Patna. Inside are operating instruments and dressings, which will be sterilised with steam generated from solar power.

Fact Box

Tripolia Social Service Hospital, Patna

Type of technology:	Concentrated solar power (CSP), solar thermal water heaters, solar photovoltaic.
Uses:	Sterilisation of hospital equipment and laundry, hot water for baths and medicines, streetlights, indoor lighting, fans and computers.
Beneficiaries:	Tripolia has beds for up to 250 patients, and an additional 200 staff and students live on campus, supported by its infrastructure.
Source of energy:	Sunshine. One square metre of solar radiation, concentrated to a point, can generate 500W of power through transferral of the sun's heat. Solar photovoltaic systems generate energy from the sun's light (see box below).
Requirements:	Roof or garden space, clear of the shadow of nearby buildings.
Cost:	Varies depending on the size and requirements of the system. SAAP currently provides one $10m^2$ parabola for Rs. 65,000.
Funding:	The hospital purchased all systems with private funds.
Savings:	The combined solar appliances save the hospital an estimated 40% on their electricity bills.
Contact:	Father Paul Mariadass, Director, SAAP. Mobile: +91 9430830108. Email: mail@solarvihar.com.

Capturing the sun's energy

Solar thermal technology harnesses the heat energy of the sun. Solar water heaters or parabolic concentrators such as those described in this story are examples. The heat from the sun is directly transferred to a medium whose temperature increases as a result. There is no electricity generation involved.

Solar photovoltaic technology harnesses the light energy of the sun. Solar photovoltaic panels contain semiconductor cells, which convert incident sunlight into direct current electricity.

Solar energy technology is expensive and tends to involve high capital investments, particularly if investing in photovoltaic technology. The Government of India, through the Ministry of New and Renewable Energy, is rolling out a "National Solar Mission" that aims to subsidise solar energy in the short run and bring its costs down in the long run.

Addendum

Use of biomass as a fuel

Case study 1 describes a decentralised model of electrification using biomass gasification technology, with “agri-waste” as feedstock. 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.

Image: Filters used to eliminate solid particles and tar from the gas generated at an 8kVA power plant owned and operated by Husk Power Systems Pvt Ltd. The process of biomass gasification is simple: these box filters contain sawdust and cloth.