



Husk Power Systems

Power to empower



Date of creation : 2008

Location : Patna, Bihar, India

Nb staff : 375 people

Nb of plants installed : 91

Installed capacity : 25,6 MW

Beneficiary households :
an average of 400 (per plant)

FY 2012 revenues:
~US\$ 540.5k (revenue from
BOOM and BOM)

Business model :
Biomass & Solar mini-grid with a
low cost Pay-for-use service ap-
proach

CASE STUDY

Established in 2008, Husk Power System is a decentralized power generation and distribution (micro-grid) company serving, in an holistic manner, rural India. It provides off-grid rural renewable electricity solutions (Biomass & Solar) as well as strives for the capacity building and the economic development of rural people (through Husk Power University & the development of new income streams to support sustainability and value creation).

EXECUTIVE SUMMARY

Established in 2008, Husk Power System is a decentralized power generation and distribution (micro-grid) company serving, in an holistic manner, rural India. It provides off-grid rural renewable electricity solutions as well as strives for the capacity building and the economic development of rural people (through Husk Power University & the development of new income streams to support sustainability and value creation). It installs 10kW to 120kW “mini power plants”, using either biomass or solar technology, and then wires villages and hamlets of up to 4000 inhabitants to deliver electricity on a pay-for-use basis. (1)

It has developed an innovative biomass gasification (1st power plant that ran on 100% producer gas) capable of generating power as efficiently as conventional biomass gasifiers, but on a microscale—enabling the company to serve rural villages at prices they can afford.

Date of creation :	2008 (1st power plant in August 2007)
Operation area :	Patna, Bihar, India & Nepal & Uganda, Africa
Nb staff :	375 people
Nb of plants installed :	91
Installed capacity :	25,6 MW
Total beneficiary :	40 000 households
Revenue for 2012:	US\$ 540,5k
Business model :	Biomass / Solar mini-grid with a low cost Pay-for-use service approach
Average time to set up a plant :	1 month + 2 months preparatory study
Collection frequency & timing :	Monthly up-front collection
Technology type :	Biomass gasification with pure biomass engine
Revenue collection :	Day-to-day village payment collector or pre-paid electricity coupon
Target Market :	Non electrified rural villages Primary : Household Secondary : Local Business
Funding sources :	Self-funded / Business Plan Competition prize money / Grants / Social Investors
Legal Incorporation :	Private Limited



Economical impacts

At user level

- Kerosene use cut by 6-7 litres/month
- Net monthly saving of Rs100 (<US\$2).
- Ancillary revenue (local HPS workers, incense manufacturing, rice husks sales for millers)

At plant level

- **Employment** : 4 employees / plant
- **Total landed costs of installation** : < \$1,300 per kW
- **Operational Cost** : Including both generation and distribution, levelized cost of electricity < \$0.15/kWh
- **Operational profitability** : 2-3 months to reach
- **Capital expenditures** : Full breakeven in 2,5-3 years with subsidies
- **Equipment lifetime** : 12 years for gasifier, 20 years for engine and 1-2 years for bamboo poles

At company level

- **FY 2012 revenues** : ~US\$ 540,6k
- High corporate overhead costs as a result of a fairly large, top-tier management team.
- **Growth in the 1st trimester of 2013** : 25 000 new Households connected with solar grid & 30 more biomass gasifiers

Social impacts

- Access to reliable, safe and clean electricity for 200k beneficiaries, via a rapidly growing number of mini-grids powered by biomass or solar power plants.
- Real positive impact in selected villages : improvement of health conditions, raise of connectivity through internet & mobile phone
- Relatively high penetration rate (70-80% in mature power plant)
- Focus is mostly in unelectrified villages in India's low-income states, including Bihar, Uttar Pradesh, Orissa, and Jharkhand. Systematic usage of prepaid meters to improve compliance and reduce theft

Environmental impacts

- Overall kerosene saving of 2.7 million litres/year cuts greenhouse gas emissions by 8,100 tonnes/year CO₂.
- Further CO₂ saving from reduced use of diesel (18,000 litres of diesel per year).

Innovations

- Proprietary gasification technology in single fuel mode
- Low cost mini-plant monitoring system via internet
- In-house information management system customized for distributed operations
- Gasifier, infrastructure and network made of local and low cost material

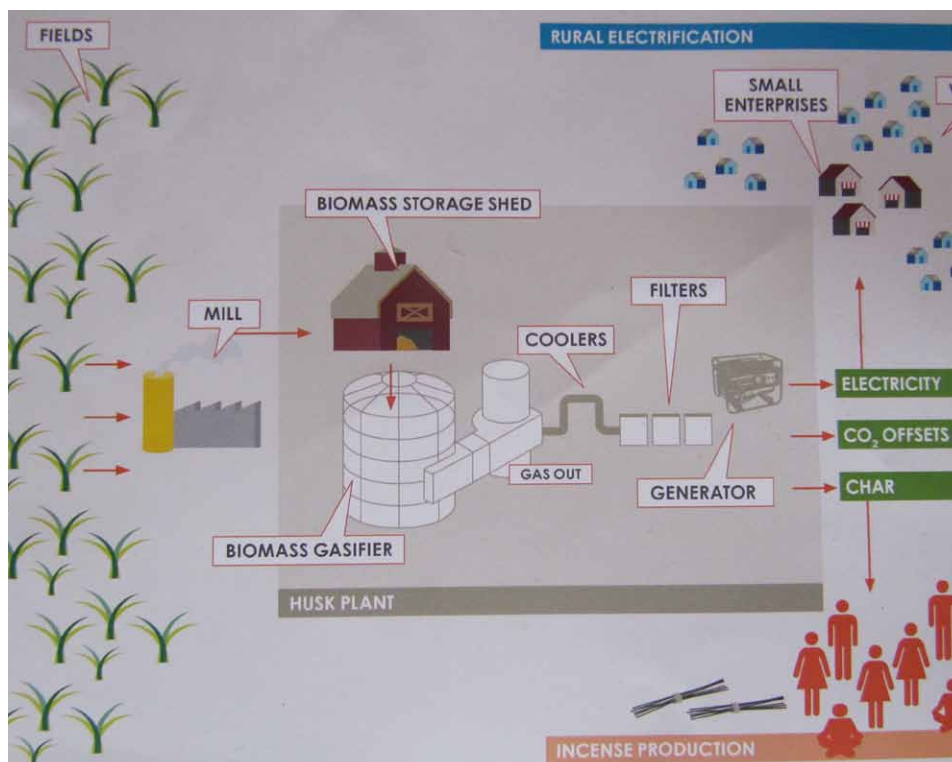
PROBLEM TACKLED AND MAGNITUDE OF THE PROBLEM

More than 24% of the Indian population still doesn't have access to electricity and more than 70% are still relying on traditional biomass for cooking. In addition to that, India suffers from a serious shortage of electricity, and people living in villages suffer the most.

In 2011, more than 74 million rural households (44%) lacked access to electricity and even where the grid extends, the supply is unreliable and does not reach all households.

When grid rationing takes place, villages often receive power only after midnight when 'priority' demand from cities and industry is low. This is of little use to rural households and businesses.

These problems are particularly acute in the state of Bihar, India's third largest state (with 83 million residents) and also its poorest (with average per capita income of \$450 per year, so in average 1,25 dollar a day). Bihar is very rural, with 85% of its citizens living in villages. Only 10,4% of rural households have access to electricity. Those without are forced to rely on kerosene, wood, and dung for their household energy needs and diesel for their agricultural and commercial energy needs. These alternatives are costly and cause health hazards like indoor air pollution. *(Indoor pollution caused by biomass burning causes almost 1.5 million premature deaths/year - more than malaria or tuberculosis)*



HPS TARGET MARKETS ARE PREVIOUSLY UNELECTRIFIED VILLAGES IN INDIA'S LOW-INCOME STATES, MOST OF HPS TARGET CUSTOMERS EARN AROUND \$5 TO \$6 A DAY AND ARE DEPENDENT ON AGRICULTURE FOR THEIR SUBSISTENCE

ID CARD

Human Resources

- 375 people in total
- **Head office in Patna** : around 20 people
- **Power plant level** : 4 staff for each power plant
 - * 1 plant operator (operates and realizes the small maintenance)
 - * 1 plant electrician (for both the plant and the costumers' houses repairs)
 - * 1 husk loader
 - * 1 day to day collector (payment collector + aftersale service)
- **Cluster** : One mechanical engineer every 5 plants (maintenance, reporting, consolidation)

Main product

For Households :

With its biomass power plants, HPS supplies, on a flat-rate approach and during a predefined period of time of 6 hours (17/18h -> 23/24h), a three-phase electricity using a 220-volt system. The main product is sold Rs150 (2,5-3 \$/month) for a 30W package (2 CFL + 1 plug for cellphone recharge) (which represent a 60W apparent power due to a cos ϕ of 0,5)

For local businesses :

In order to provide day & night electricity to their business customers, they use a parallel system based on solar (solar power plant of 5kW on batteries or with a 5KVA inverter).

Business Model

Low cost Pay-for-use service approach is being followed by HPS for raising revenue and supplying electricity :

- Demand for affordable, reliable electricity in rural India
- Ready supply of husks left over from rice processing, as well as other biomass, with few competing uses
- Government support for off-grid energy solutions

BOOM - Build, own, operate, maintain:

HPS builds, owns, operates, and maintains the power generation and distribution system, with revenues coming from subscriber fees. It typically takes two to three months for a plant to reach operational profitability, and three to four years to recoup capital expenditures, depending on whether (and how much) subsidy is received. Additional revenue streams come from the sales of silica or rice husk ash (to be mixed in cement or used to produce incense sticks) and, starting in 2012, carbon offsets. Each of these revenue streams could add up to 50- 60% to the total margins of each plant.

BOM – Built Owned and Maintained :

HPS builds, owns and maintains the power generation and distribution system but the system is operated by a local who is willing to put in 10% of the project cost.

BM - Build and maintain:

HPS builds and sells the system to an independent owner-operator. This model is closer to the conventional franchisee model. The owner-operator is responsible for all costs and entitled to all revenues. Staff training is included in the purchase price, and maintenance and repair are provided on a fee-for-service basis. For a share of the revenues, HPS will also facilitate marketing of rice husk ash and obtaining carbon credits. HPS also facilitates access to Indian government subsidies available for rural electrification, which can cover up to 50% of the total project cost.

Penetration rate

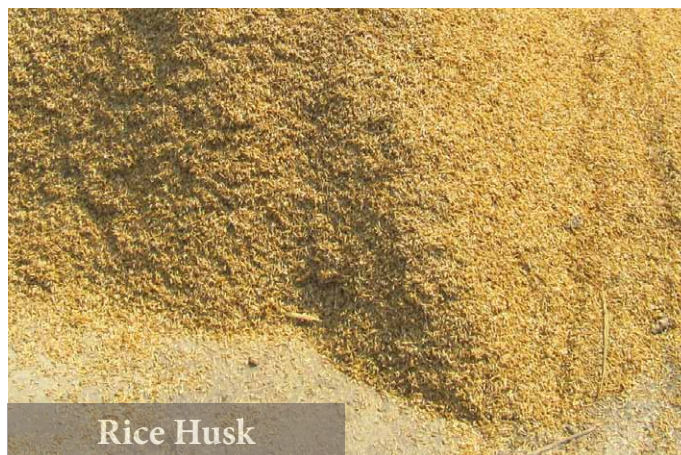
At maturity, the average penetration rate in villages with a biomass power plant at oscillates between 70-80%.

Revenue Model

Sources of revenue :

- Electricity sales
- Rice Husk Char which is a by-product of Biomass gasification process (monetized by making incense sticks and Silica precipitation used in cement)
- Channeling of product in rural markets (actually tested)
- Certified Emission Reduction (CER) and Verified Emission Reduction (VER) sales

1. The 10 kW power plants are used for cellphone towers
2. For customer with greater needs (e.g.: markets), a cheaper package is also available and is priced at a significantly lower rate of \$0.40 per CFL (HPS power plants operating for longer hours, e.g: 12h, during the day)
3. Subscribers can pay more, at \$1.10 for each additional 15W connection, if they have appliances requiring greater wattage.
4. The frequent replacement of bamboo poles is due to erosion due in part to moisture. HPS sees it as an opportunity to provide ancillary revenue to the community who provide the bamboos.



Rice Husk

Billing principles :

- Customers must pay a connection cost (between \$2 or \$3 depending on the local context) to take the distribution network to their homes, and purchase the light bulbs that they use.
- Customers only pay for the electricity that they use. (2)

Average billing :

- Average household subscribers pay Rs.150 (between US\$2 to \$3) for 2 CFL's and cellphone recharging. (3)
- Business subscribers tend to use more electricity, between 60-75W, paying an average of \$4-4.50 per month.

Economic Sustainability

HPS Total Landed Cost of Installation : < \$1,300 per kW (4)

Unit cost to the end user: about \$0.25 per kWh

Operational Cost (for a 32kW plant) :

- Average monthly biomass feedstock : \$275
- Average monthly cost of labor : \$380
- Average monthly maintenance expenses : \$100

Including both generation and distribution, HPS can provide electricity at a levelized cost of < \$0.15/kWh

Average monthly revenue/plant (for a 32kW plant) :

Average monthly electricity sales : \$1200

- Average annually carbon credit : 215 CER
- Average monthly sales of biomass product : 6t of incense sticks

Sustainability :

- HPS is profitable at the plant level - Gross Margin : 20%
- It typically takes 2 to 3 months for a plant to reach operational profitability and 2,5 to 3 years to recoup capital expenditures with subsidies
- Corporate overhead costs are high as a result of a fairly large, top-tier management team.

Expected lifetime of the power plant and bamboo network :

Gasifier : 12 years, Engine : 20 years, Bamboo poles : 1/2 years (4)

As a Lighting-focused mini-utility, HPS can estimate relatively easily load curves based on demand, making plants more efficient. This might facilitate scalability but limits profitability, since households are lower-profit, lower consumption customers.



VALUE CHAIN OF BUSINESS

Raw material

Mainly rice husks purchased from and delivered at HPS plant by centralized rice mills or from local cooperative at a year-round price cheaper than Rs150 per kg (less than \$0.03 per kg). 50 kg/hour of rice husk is required as raw material for a 40kVA power plant (so 300kg for 6h). HPS is beginning to use a mix of rice and wheat husk, and is also adjusting its plants to use bagasse, sawdust, jute, and other biomass fuels.

Technological innovations :

Proprietary gasification technology "in single fuel mode" to convert agricultural residue into electricity:

- **Multi-fuel gasifiers:** Gasifiers can use multiple types of feedstock such as rice husk, wheat husk, mustard stems, corn cobs wood chips...

- **Unique gasifier design:** allows for easy disposal of biomass char, lack of which results in tar formation;

Remote Plant Monitoring System : low cost system to monitor plant performance via internet;

Pre-paid meters : Cheapest pre-paid meter at US\$8 per consumer. Enables electricity to be sold like mobile phone talk-times where consumers get their meter charged with the amount of money they have and the meter automatically disconnects supply after the credit is exhausted;

Management Information System : Unique in-house developed management information systems customized for distributed operations. It interfaces data through multiple input sources such as cell phones, monitoring hardware and computers.

Cost reduction innovations :

- Gasifier fabricated at a local workshop and CNG modified engine procured from a small supplier
- Infrastructure cost of the power plant reduced with the used of locally available and low cost material instead of usual brick and concrete
- Electricity distributed through micro-grid made from bamboo or other sustainable material

Sack loads of rice husk or other biomass residues are poured into the gasifier hopper every 30 to 45 minutes. The biomass burns in a restricted supply of air to give energy-rich producer gas. The gas passes through a series of filters which cleans it, and it is then used as the fuel for an engine that drives the electricity generator. Electricity is distributed to customers via insulated overhead cables.

A typical plant can serve two to four villages—approximately 500 households—within a radius of 1.5 kilometers, depending on size and population.

Largely by word-of-mouth and also through local press and media -> HPS receives several hundred enquiries about installations each year.

The request usually comes from a community or the government. 2 or 3 HPS staff visit a village, at the invitation of village representatives, to assess its suitability for a plant and explain how the scheme works. Then HPS realizes some "installation reviews" if :

- 400 or more households commit to paying a monthly fee for electricity (HPS secures commitments for household connections before starting operations in a new area, asking for a deposit of one to three months' consumption to ensure that customers are able to make payments),
- there is a reliable source of rice husk and other biomass residues within a distance of 10 km,

Usually after a 3 month installation process, HPS installs a plant (rice-husk gasifier, gas engine, generator and 220 V or 440 V electricity distribution system) and connect the homes and small businesses that have signed up. This installation usually takes up to 1 month. For each customer's private installation, HPS makes sure that they understand how to use electricity safely, and that every member of the household agrees to abide by safety rules. A village operating team maintains and runs the system, which supplies electricity each evening for up to six hours.

Monthly up-front collection of payments by incentivized door-to-door collectors, who double as electricians

- Smart meters installed on subscribers' premises allow non-payment to be kept under 5%—compared to a national average of approximately 30%.
- Circuit breakers directly connected to pre-paid meters are designed to cut off the flow of electricity if it exceeds the designated level, and resume when it returns to normal. A fine of Rs.10 is charged for restoration.

For solar grid: The recharge of the pre-paid meter is realized by buying a coupon and entering the number from this coupon on the pre-paid meter keyboard

High availability of power (over 93% of scheduled time) due to design of equipments, and the rigorous maintenance, safety and monitoring procedures instituted by HPS.

Tars and other particulates in the producer gas can damage equipment, in particular engines so a key factor for successful operation is the rigorous HPS maintenance programme. This schedules cleaning and maintenance tasks on a daily, weekly, monthly and quarterly basis. HPS also requires high safety standards and detailed monitoring, with individual plant managers sending a daily report to the manager of their local 'cluster' of four or five plants, and the cluster manager relaying data to the regional level and onwards.

R&D & Innovation

Operations

Marketing

New plant installation process

Billing & Payment

Maintenance

IMPACT TO DATE

Social impact

Good-quality lighting : Having a reliable electricity supply makes families feel more settled and connected to the wider world. Even in villages with grid power, households and businesses choose to connect to the HPS supply because of its greater reliability and lower cost. Throughout the evening, it is a huge benefit to households: Children can study properly, housework is easier, and families can relax and socialise. Better lighting deters petty crime, and reduces the frequency of snake-bites and dog-bites – a common reason for emergency hospital admission in Bihar.

Health : Removing kerosene lamps reduces exposure to smoke and fumes (indoor air pollution) improving health conditions in rural areas, and the risk of fire. (Many village homes are built from woven bamboo, and house fires are common in rural Bihar)

Mobile phones : They are important for business and keeping in touch with the many family members/friends. *(In 1 village, mobile phone ownership increased from 10% to 80% of households after the HPS supply was installed. Indeed, previously people had to go out of the village to have their phones charged)*

Economical impact

Household : Kerosene use cut by 6 to 7 litres/month - saving about Rs250 per month (US\$4.40 per month). So their net monthly saving (after paying for their CFLs and plug) is about Rs100 (a little less than US\$2).

Businesses : they benefit from better quality lighting and electric fans. Some new businesses have even started because of the HPS supply, including cyber-café, photocopying shops and mini-cinemas.

Rice mills : They are paid about US\$25 per tonne of rice husk, so earn an extra US\$2500 - US\$3,000 per year by supplying an HPS plant, as well as solving a disposal problem. Some mills have shared this benefit with their customers by cutting the charges that they make for milling.

Environmental impact

Overall kerosene saving of 2.7 million litres/year cuts greenhouse gas emissions by 8,100 tonnes/year CO₂. Further CO₂ saving from reduced use of diesel (18,000 liters of diesel per year).



Job creations

HPS ensures that jobs are created for local communities. Plant assembly provides temporary employment for about 10 local labourers. Then the company hires local villagers for maintaining and operating the power plants. Each plant then employs 3 or 4 people (plant operator, electrician, fuel handler and fee collector) who have training, income and safe working conditions. Further skilled and professional employment is provided in the cluster-level, regional and central operations. HPS provides full medical benefits and retirement contributions for its full time employees.

Capacity building

HPS has invested almost \$500,000 in a capacity-building venture called “Husk University,” which aims to develop enough trained entrepreneurs to efficiently run its systems using a combination of classroom and on-site programs.

CSR program

Livelihood programs : such as incense stick manufacturing programmes with the ash that is the by-product of the biomass plants.

HPS initiative has provided employment opportunities to thousands of rural women by giving them training and raw material to manufacture incense sticks (using rice husk char). As of now, more than 1200 women have been trained (at 2 plant sites) for manufacturing incense sticks. This enables household to earn up to Rs 1000 per month.

Education : HPS has facilitated the education of children of local communities by paying school-fee of Rs 50 per month.





ECOSYSTEM CONDITIONS

Corporate finance

HPS is one of the few mini-grid companies to secure formal equity investment, but still it has mostly financed its capital and operating costs from grants and some equity from the owners. HPS is struggling to secure the capital needed to develop its franchise approach because banks are simply not willing to take the risk on such an early-stage venture.

In 2008, HPS added three new power plants with \$100 000 in winnings from business plan competitions and grant funding from the Shell Foundation.

In 2009, operations were expanded to 19 power plants with \$1.65 million raised from six social investors (Acumen Fund, Bamboo Finance, International Finance Corp, Draper Fisher Jurvetson, LGT Philanthropy and CISCO).

HPS managed to secure a \$750 000 loan from the U.S.-based Overseas Private Investment Corporation (OPIC)

In October 2012, HPS has raised US\$5 million for its expansion.

Subsidies

HPS is paid a subsidy of up to INR Rs.780 000 (\$14 500) for each 32KW plant by the MNRE-Ministry of New and Renewable Energy (Govt. of India)

NB : But it takes lot of time and there is always uncertainty regarding the obtention of the subsidies from the MNRE

Legal / Regulatory

- An interstate tax policy on technologies and products is acting as an impediment for dissemination of renewable energy technologies.
- Government offers a subsidy of US\$0,5 per liter. The kerosene price pre-subsidy is US\$0,8 and post subsidy is US\$0,3 per liter
- MNRE - Ministry of New and Renewable Energy (Govt. of India) provides subsidy to renewable energy projects to promote them.

Competition

Grid based power is not a competition to off-grid renewable energy systems because of high demand for modern energy services and low availability of power in the grid.

Carbon finance

Carbon payment is estimated to contribute about 5 percent of revenues today (215 CER's/32KW plant/year), by 2014 it could account for as much as 50 percent of total sales.

CURRENT CHALLENGE

- Initially, HPS was unable to find low-cost transformers for subsystems and faced a similar challenge with circuit breakers. The company, therefore, has invested significantly in R&D, crafting a number of tailored solutions in partnership with Indian engineering colleges and other local experts. This technology has significantly reduced investment costs, but also led to higher operating and maintenance costs, which the company is now struggling to better manage.
- An interstate tax policy on technologies and products is acting as an impediment for dissemination of renewable energy technologies.
- HPS saw rice husk feedstock prices rise about 35 percent in 2011 because it has not been able to secure long-term contracts for reliable supply.
- Availability of trained work force at the local level is critical for sustainability renewable energy systems.
- In order to scale-up, HPS must have a growth-oriented business model and a high calibre management team to design and oversee a complex rollout -> investment in strategy, formal management skills, customized information systems to manage a growing span of control, and a tailored training program for operators and mechanics to run new plants become critical.

ANNEXE 1 : FIELD OBSERVATIONS

Location

Village name & location :	Tamkuha in Bihar's West Champaran district
Number of households :	1100
Population :	5400
Occupation :	Agriculture and ancillary activities
Accessibility :	Accessible by road - 7 hours drive from Patna
NGO Footprints :	None
Nearest market :	22 kms
Main crops :	Paddy, Wheat, Gram, Vegetables
Households income :	monthly average of \$5 to \$6 a day
Access to water :	via manual pumping system - parts of the water of the village contain Arsenic

HPS' installation in Tamkuha

Launch : August 2007

Penetration rate : 70 %

Characteristic of the system of electricity production system for the village :

Biomass power plant : 32 kW + a solar power plant of 5 kW (storage in batteries and delivery through a 5 kW AC inverter) for the market place.

Technical description of the power plant :

The gasifier has a cylindrical combustion chamber with a hopper above it. To start up the plant, rice husk is poured into the hopper and flows into the combustion chamber where it is set alight. Air is drawn downwards through the husk, which burns in a restricted supply of oxygen to give energy-rich producer gas, a mixture that includes hydrogen, carbon monoxide and methane. The char that remains drops to the bottom of the gasifier and is removed every 15 days. The gas is cooled and cleaned by water coming from a 5 different reservoirs system (one reservoir connected directly to the plant where the water has to be changed every 2 months, 3 reservoirs with different filtering systems and a final disposal tank). Then the gas is drawn through three or



more filter beds made of char or rice husk, to remove tars. A final acrylic cloth filter removes particulates, before the gas is burned in an engine that drives a generator to produce about 35 kW of ac electrical power at 220V.

The engine is monitored all the time by the plant electrician, and both operator and automated controls ensure that electricity supply matches demand. The 220V distribution system uses 25mm² insulated cables for safety and also to reduce electricity theft. Cables are taken on bamboo poles to users up to 2 km from the plant: longer distances are discouraged because they lead to high losses and voltage drops in a low-voltage system.

HPS connects the supply to the user, but the household or business must pay for the internal wiring. This plant uses about 10 tonnes/month of rice husk which is collected from farmers with an HPS tractor.

HPS normally keeps one week's worth of biomass in reserve, but stocks up before the monsoon period when deliveries may be disrupted.





SEVEA – Synergie pour l'Echange et la Valorisation des Entrepreneurs d'Avenir - is a not-for-profit organisation that strives for an improvement of the answers brought to energy and water issues (from an environmental, a social and a societal perspective) in developing countries by supporting social enterprises from these sectors.

Our partners



Our references



Contact:

Sevea, Association Loi 1901

172 Chemin de Cugnet
73800 Les marches
FRANCE

www.sevea-asso.org
sevea.blog.youthil.com

@ : contact@sevea-asso.org

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