# DEVELOPMENT OF RENEWABLE ENERGY TECHNOLOGIES IN INDIA
## THE ROLE OF BHEL

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Global warming is emerging as one of the biggest challenges of this century. One of the main reasons for this is the emission of GHGs (greenhouse gases). The main source of GHGs is thermal power plants based on fast-depleting fossil fuels. Hence, there is a pressing need to go for renewable energy sources since they get replenished fast—solar, wind, hydro, biomass, and so on.

### BHEL initiatives

BHEL (Bharat Heavy Electricals Ltd) realized the importance of renewable energy sources as early as in the 1980s and took initiatives in the in-house development, manufacture, and supply of a range of renewable energy products and systems. BHEL developed a range of renewable energy products and systems like:

- Solar water heaters
- Solar cells, modules, and panels
- Solar lantern
- Wind electric generators
- FBC boiler for agricultural biomass
- Battery-powered road vehicles
- Fuel cells, and so on

BHEL is one of the few organizations that have helped in making the country free from the compulsions of importing power equipment. Practically, every third house out of four in India is supplied power generated from BHEL sets. Today, the company not only plays a key role in meeting indigenous need of conventional power plant equipment but also holds impressive record of their export.

BHEL has ventured in difficult and inaccessible terrains to establish and demonstrate renewable energy technology in power-starved areas of the country. Looking beyond business interests, BHEL has focused on remote areas in Lakshadweep, Andaman and Nicobar, Sunderban Islands, the North East, and defense locations, as a part of its CSR (corporate social responsibility) initiatives.





**Table 1 Indian RE scenario and BHEL's contribution**

| *Source/System* | *Estimated potential* | *All India achievement as on 31 March 2009** | *BHEL's contribution* |
|---|---|---|---|
| SPV Power (grid) >25 kWp | — | 2.12 MWp | 1.5 MWp |
| Small Hydro (up to 25 MW) | 15 000 MW | 2430 MW | 550 MW |
| Wind Power | 45 195 MW | 10 242 MW | 66 MW |
| Water Heating Systems | 140 million $m^2$ collector area | 2.9 million $m^2$ collector area | 53 000, 0.1 million $m^2$ collector area |
| Solar lanterns | — | 730 000 | 115 000 |
| SPV Pumps | — | 7148 | 450 |
| SPV Street Lighting System | — | 70 474 | 3600 |
| SPV Home Lighting System | — | 450 000 | 1216 |
| PV System for Rural Radio Phone for DoT | | — | 30 220 sets |

BHEL has also contributed 16 MWp in standalone SPV systems and 1.5 MWp in SPV power plants/packs.

### Indian scenario

The Indian scenario in renewable energy and BHEL's contribution is given in Table 1.

### Solar energy

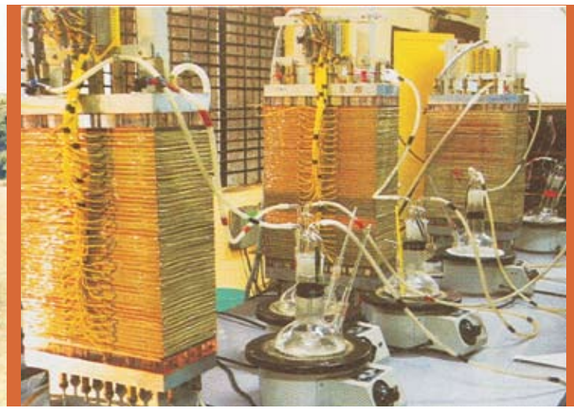
The sun provides enough energy in one minute to cater to the global energy needs for one year. India receives 5000 trillion kWh of solar energy per year.

#### Solar photovoltaic

In line with its CSR initiatives, BHEL paid special attention to the development of remote and inaccessible areas in the Sundarbans delta, Lakshadweep, and Andaman and Nicobar islands. The solar power plants commissioned by BHEL have heralded a new era in the lives of the islanders. BHEL commenced the manufacture of SPV (solar photovoltaic) cells and modules at its Bangalore plant in 1983. Subsequently, it set up standalone as well as grid-interactive SPV plants in remote areas. The company offered solar power plants ranging from few kilowatt-peaks to megawatt sizes. The company has modern manufacturing facility for semiconductor processes and fabrication lines for solar cells and PV modules and systems. This facility has been augmented to 8 MWp per year. So far, BHEL has supplied more than 21 MWp of solar equipment/systems.

BHEL's SPVs consist of 125 mm and 156 mm crystalline silicon cells and 10–170 Wp-capacity modules/panels. These products are designed and manufactured in a state-of-the-art facility and are certified by the Solar Energy Centre (MNRE, Government of India) and Electronic Technology Development Centre in India. These have also been design-qualified and type-test-certified by Joint Research Centre, Ispra in Italy, for IEC-61215 standards, which are recognized by international clients. Along with upgraded line, BHEL is manufacturing and supplying 225 and 270 Wp PV modules to cater to large rating solar power plant application.

In a recent initiative, BHEL and BEL (Bharat Electronics Ltd) signed a MoU to explore a 250-MW joint manufacturing facility for SPV cells, modules, and silicon wafers. The two companies will look for suitable vendors or partners for technology and supply of raw materials such as polysilicon. The joint venture, worth Rs 3500 crore, will cater to the

domestic as well as the growing export market for solar products.

The BHEL supply range covers the following.

- Rural SPV lighting (street and home lighting)
- Solar water pumping
- SPV railway distant signalling
- SPV system for microwave repeater stations and rural radio phones
- SPV systems for offshore platforms
- SPV systems for seismological equipment
- SPV systems for battery charging in rural telephone exchanges
- SPV systems for navigational aids
- Solar power plants (stand alone, grid interactive)
- Hybrid (PV Mains or PV Diesel) power plants
- Rooftop and building integrated PV

The SPV-based power plants supplied by BHEL are listed in Table 2.

**Table 2 The SPV-based power plants supplied by BHEL**

**A) Solar power plants with rating > 15 kWp**

| *Order placed by* | *Description and quantity of ordered equipment* |
|---|---|
| Electricity department, Kavaratti, Union Territory of Lakshadweep | (i) 100-kWp SPV grid-interactive power plant at Kiltan Island<br>(ii) 50-kWp SPV standalone power system at Bitra Island |
| Electricity department, Lakshadweep | Grid interactive power plant at<br>(i) 150 kWp at Kadmat Island<br>(ii) 100 kWp at Minicoy Island<br>(iii) 100 kWp at Agatti Island<br>(iv) 100 kWp at Kavaratti Island<br>(v) 100 kWp at Androt Island<br>(vi) 100 kWp at Kalpeni<br>(vii) 100 kWp at Amini<br>(viii) 100 kWp at Chetlet<br>(ix) 50 kWp hybrid system (50 kWp SPV + 2 x 60 kW DG) at Bangaram |
| Electricity department, Andaman and Nicobar Island | (i) 50 kWp SPV grid interactive (with standalone facility) power plant at Neil Island<br>(ii) 50 kWp SPV grid interactive (with standalone facility) power plant at Havelock Island |
| WBREDA, Kolkata | SPV Stand Alone Power Plants at :<br>(i) 55 kWp at Mousuni Island<br>(ii) 110 kWp at Mousuni Island—St.-II<br>(iii) 110 kWp at Rakhalpur<br>(iv) 55 kWp at Tushkali<br>(v) 110 kWp at Kaylapara<br>(vi) 55 kWp at Daudpur<br>(vii) 55 kWp at Pathankali |
| APSEB, Hyderabad (now APGENCO-APTRANSCO) | 100 kWp SPV grid interactive power plant installed at APTRANSCO HQ |
| ANERT, Thiruvananthapuram | 25 kWp SPV grid interactive power plant installed at KSEB HQ |
| ESD, Bangalore | 30 kWp SPV grid interactive power plant |
| HRDI, Noida | 65 kWp SPV grid standalone power plant |
| Sirifort, New Delhi | 25 kWp SPV grid standalone power plant |





**Table 2 The SPV-based power plants supplied by BHEL *(coninued...)***

**B) SPV power plants with rating < 15 kWp (major orders)**

| *Order placed by* | *Description and quantity of ordered equipment* |
|---|---|
| Jharkhand State Tribal Cooperative Development Corporation Ltd | 174 SPV standalone power systems aggregating to 614 kWp |
| HPCL, Mumbai | 50 x 5.94 kWp SPV standalone system for fuel outlets |
| Chhattisgarh Renewable Energy Development Agency | 26 SPV standalone power systems aggregating to 130 kWp |
| Karnataka police | 300 grid-connected solar power packs for police stations aggregating to 67.5 kWp |
| Chhattisgarh State Electricity Board | 9 SPV standalone power systems aggregating to 36 kWp |
| NTPC, Rihand | 11.9 kWp standalone SPV plant at Jarah Chetwa Village at Sonbhadra District, Uttar Pradesh |

### Lighting system

The Rudrapur plant started manufacture of solar lanterns since 1992/93 and supplied over a lakh lanterns. BHEL supplied a large number of PV street lighting systems, home lighting systems, and school lighting systems to Tamil Nadu Electricity Board, Karnataka Electricity Board, various Islands, Tamil Nadu Energy Development Agency, Maharashtra Energy Development Agency, Pondicherry, Itanagar, and so on.

### Water heating systems

BHEL developed flat collector-type SWHS (solar water heating system) in 1985/86. In the course of development, required changes were made in the processes and materials. A dedicated facility was established at Rudrapur, Uttarakhand, to manufacture SWHS, solar lanterns, and other such products. At present there are more than 100 manufactures of SWHS with flat plate collectors in the country.

## Battery-powered road vehicles

BHEL developed battery-powered vehicles through in-house R&D (research and development). BHEL has supplied about 450 BPRVs (battery-powered road vehicles) generally to public sector undertakings and few in the private sector. BHEL also developed special purpose tailor-made VVIP coaches for various zoos and so on. Further, as a part of improvement, on-board charging facility of the batteries was added. BHEL supplied BPRVs to various customers such as Delhi Development Authority, Agra Development Authority, IIT Chennai, Pathnitop in Jammu and Kashmir, and the Parliament House.

## Small hydro

BHEL started design and manufacture of hydroelectric equipment at Bhopal and Haridwar in 1966. It had the responsibility of assimilating the collaborator's technology of hydroelectric equipment. Looking at the total hydropower potential in India, BHEL's contribution as on 31 March 2009 was 365 sets totalling 16 996 MW. BHEL has not limited itself to higher/medium rating machines but has also addressed the mini/micro/small hydro needs of the utilities for special areas as

per their requirement. In small hydro, BHEL entered into a new arena and paved the way for others.

- Smallest rated bulb turbines of 6 x 1.692 MW for Sone Link Canal Project in Bihar
- Smallest rated Pelton turbine of 3 x 1.5 MW for Yazali Project, Arunachal Pradesh
- Highest speed (1500 RPM) Francis turbines for 2 x 1.5 MW for Gumma project in Himachal Pradesh
- A 100-kW tubular turbine for Kakroi to Alternate Hydro Energy Centre, Roorkee, for educational purpose

- Propeller turbines for 2 x 1.4 MW Dhupdal Project in Karnataka

## Wind power

For over a decade, wind energy has been the fastest growing renewable energy source in India. BHEL took the extraordinary initiative in the field of wind electric generator when its technology was in the primitive stage in the country. The manufacturing of 200/250 kW wind turbines was taken up at BHEL's Boiler Auxiliary Plant, Ranipet, in collaboration with M/s Nordex A/s, Denmark. BHEL has also supplied to wind farms in the states of Tamil Nadu, Gujarat, Andhra Pradesh, Maharashtra, and Rajasthan.

### Dual-speed generators

Wind power varies along the length and breadth of the country with the location, altitude, seasons, day temperature, and so on. In order to utilize wind energy efficiently, generators should be designed to operate at more than one discrete speed. To harness wind power at high as well as low wind speeds, BHEL has developed both the options as per customer specifications. The company has successfully designed, manufactured, and tested a 200 kW/50 kW, 6/8 pole dual speed wind electric induction generator.

## Developmental activities

### Amorphous Silicon: Gurgaon

R&D in SPVs first started at BHEL's Bangalore plant. Subsequently, a world class R&D facility was developed at Gurgaon to carry out research in the field of mono, multi, and thin-film silicon photocells. BHEL has developed 6" x 6" size modules, one of the biggest in the world. It also has the facility to develop suitable texturizing technology.

### FBC boiler

More than 70% of India's population depends on agriculture, which results in huge biomass waste. The economically viable conversion of biomass into energy has been a challenge. BHEL accepted this challenge and developed a 10 MW rice straw-based FBC (fluidized bed combustion) boiler for the first time in the country. This project was jointly funded by DNES (Department of New Energy Systems), Punjab State Electricity Board, along with BHEL.

### Fuel cell

In 1988, BHEL became the first company in India to take up fuel cell-related projects in the R&D division in Hyderabad. India's largest ever 50 kW PAFC power pack was tested at BHEL R&D during December 2000. BHEL acquired basic PEMFC technology from the IISc, Bangalore, in 2002 and developed 3 kW PEM fuel cell. BHEL installed a fuel cell plant for demonstration at BPCL's petrol pump near Hyderabad. Apart from low temperature PAFC and PEMFC, BHEL is taking initiative to develop SOFC (Solid Oxide Fuel Cells), which work at high temperature at its Ceramic Technological Institute, Bangalore.

### Hybrid systems

BHEL has developed a master controller, which will ensure proper operation of the standalone wind-SPV-diesel hybrid system and allow maximum utilization of wind and solar powers, while minimizing the usage of diesel. Keeping





focus on areas that do not have access to the grid, a 100-kW hybrid system integrating wind, SPV, and diesel has been commissioned at Kavadakallu in Anantpur district in Andhra Pradesh. This technology, developed for the first time in the country by BHEL's Corporate Research and Development Division, is undergoing field trials for low and high wind applications with a provision of automatic changeover.

### Building integrated SPV laminates

A process for glass-to-glass and glass-to-tedlar lamination has been developed at BHEL's SPV development centre ASSCP for making semi-transparent and opaque laminates for integrating with windows, canopies, and roofs of buildings. This will allow natural light to permeate, minimizing dependence on electric lights, in conformity with 'green building' concepts. These have been put on a room in the BHEL's ASSCP.

## Conclusion

BHEL, apart from taking initiatives in the field of renewable energy, has been developing new technology and products to demonstrate and build up the confidence of the entrepreneur to enter these areas like solar lantern, solar heaters, WEG, and battery-powered road vehicles.

### Key contributions

The major contributions of BHEL to renewable energy have been:

- **HPCL**: BHEL supplied SPV systems to M/s HPCL to illuminate and run the company-owned petrol dispensing stations smoothly, irrespective of grid power outage. The design takes care of four dispensing stations to work for at least four hours, even when the grid power is not available.
- **Lighting**: BHEL was the first to commission India's largest 105 kW standalone SPV power plant at Mousini Island in South 24-Parganas district in West Bengal on 5 April 2003. It was aimed to fulfill electricity and drinking water need of 700 homes.
- **SPV Water Pumping System**: BHEL has supplied fixed structure type systems to the Gujarat Energy Development Agency and Government of Tripura, and manual tracking type systems to Orissa Renewable Energy Development Agency, Tamil Nadu Energy Development Agency, Non-conventional Energy Development Corporation of Andhra Pradesh, DRL (Assam), Madhya Pradesh Urja Vikas Nigam Ltd, and Agency for Non-Conventional Energy and Rural Technology.
- **Transportation**: With inherent technological strength, BHEL took development of BPRV buses as a pilot project at BHEL, Bhopal. After several engineering/manufacturing trials, first bus was rolled out in early 80s. Improvements continued in load capacity, charging intervals, and a modern BPRV took shape.
- **Tsunami crisis – emergency supply of solar lanterns**: During Tsunami crisis, BHEL sent 6000 solar lanterns through air to Andaman against government order to serve lighting needs of people when the established power systems were wrecked.
- **Smart Card**: A novel method of selling electricity has also been adopted at Mousuni Island by employing prepaid energy meters on trial basis. Energy is being sold through smart cards to selected

customers who are uniquely identified with the energy meter installed in their premises.

- **Small hydro**: Installed in remote areas like Stakana and Karnah in Jammu and Kashmir, Tripura, and so on. In order to economize the cost, a load controller was developed for the first time to replace governor, which has been subsequently adopted by other manufactures.
- **Meeting challenges in space**: BHEL has tied up with ISRO (Indian Space Research Organization) to fabricate space-quality solar panels and batteries. This is an extension of its terrestrial solar cell project, and involves assembly and testing of high-efficiency, high-reliability solar panels and batteries for use in outer space.

For efficient utilization of renewable energy and to minimize dependence on conventional power, governments at both the central and state levels may take policy decisions in the following areas.

- Police check posts, primary health centres, offices of gram panchayats/ BDOs, and primary schools in rural and backward areas should be based completely on solar systems.
- All rural petroleum outlets of IOCs, HP, BP, and so on should be made 100% solar/hybrid.
- Traffic signalling/marking requirements in all major cities should be made SPV-based.
- All defense establishments in remote areas should be covered under solar/solar-hybrid lighting.
- Defense locations in difficult terrains, especially in the Himalayan region, should be identified with suitable mini/micro hydel plants to meet the power needs and other associated spin-outs like fishing.
- In the sensitive tribal areas, initiatives could be taken for solar, hybrid, and mini/micro hydel plants with total involvement and management of local people to provide creative alternative besides meeting power needs.
- BPRV in small and medium capacity configuration be made mandatory for use in tourist areas and by leading hotels for pick-ups/drops for their customers, PSUs for in-house requirement, and so on.
- All hoardings in metros, to start with, should have mandatory solar-powered lighting system.

## DID YOU KNOW?

In the late 15th century Leonardo Da Vinci already conceived of an industrial use of solar power by employing concave mirrors to heat water.

In 213 BC, the hero Archimedes used solar energy to save Sicily, then called Syracuse, from Roman warships in an ambitious and unusual plan. He used mirrors to concentrate and reflect the energy from the sun onto the Roman ships, and to set them on fire so they were no longer a threat.





# Solar Village - Iqbalpur

Village Iqbalpur is located near the famous Sultanpur Bird Sanctuary. It is about 15 km from Gurgaon, and comprises of about 120 families engaged in farming and related activities, such as dairying and animal husbandry. Though located near Gurgaon, the village is not different from any other remote village as far as electricity is concerned. It faces several power cuts at crucial hours.

The Sultanpur branch of GGB (Gurgaon Gramin Bank), after getting a call from its corporate office, decided to popularize SHLS (Solar Home Lighting Systems) in its operational area. Initially, it was a stupendous task to motivate the people of nearby villages to install SHLS. So, to demonstrate the utility and effectiveness of SHLS, the branch decided to install a system in its own premises so that villagers can themselves see and realize the advantages of SHLS.

The Village Pradhan of Iqbalpur also visited the Sultanpur Branch. The Branch Manager convinced him about the utility and working of SHLS. Together, they decided to hold a meeting in the village and demonstrate the SHLS.

Subsequently, a demonstration was organized in the village with the assistance of TATA BP Solar Pvt. Ltd. Apart from the demonstration of the working of the systems, the credit scheme of the Bank for purchase of such systems was also explained in detail.

Initially, about 10 units were installed. Soon, other villagers also came forward to install SHLS with the financial assistance provided by the Sultanpur Branch of GGB. Collateral-free, hassle-free, and without-margin credit facility was extended under 'GGB Saur Vidyut Scheme' of the bank. Now every household in the village has installed a SHLS.

*N T Hegde, Chairman, GGB*

**GURGAON GRAMIN BANK'S 'SAUR VIDYUT SCHEME'**

**Major attractions and specialties**

1. GGB provides loan to its existing and new customers to purchase TATA BP Solar Lighting System on easy conditions and at cheaper interest rates.
2. Loan amount : up to 85%-95% of the total cost
3. Repayment of loan : up to 5 years
4. Service charges : up to Rs 100 only
5. Security : Supervision of solar lighting systems
6. Guarantor : a reputed person

**Status position of Branches' contribution in promotion of Solar Home Lighting Systems under 'GGB Saur Vidyut' scheme**

| Sl. No. | Branch name | Total unit sanctioned | 100% coverage of SHLS |
|---|---|---|---|
| 1 | Kharkhoda | 251 | Gopalpur village |
| 2 | Mohindergarh | 159 | Ballayacha village |
| 3 | Sultanpur | 154 | Iqbalpur village |
| 4 | Seehma | 121 | |
| 5 | Katesra | 101 | |
| 6 | Gharoda | 100 | |
| 7 | Badoli | 80 | |
| 8 | Haily Mandi | 75 | |
| 9 | Mandkola | 70 | |
| 10 | Mohna | 67 | |
| 11 | Kushak | 60 | |
| 12 | Rawli | 60 | |
| 13 | Dhanonda | 60 | |