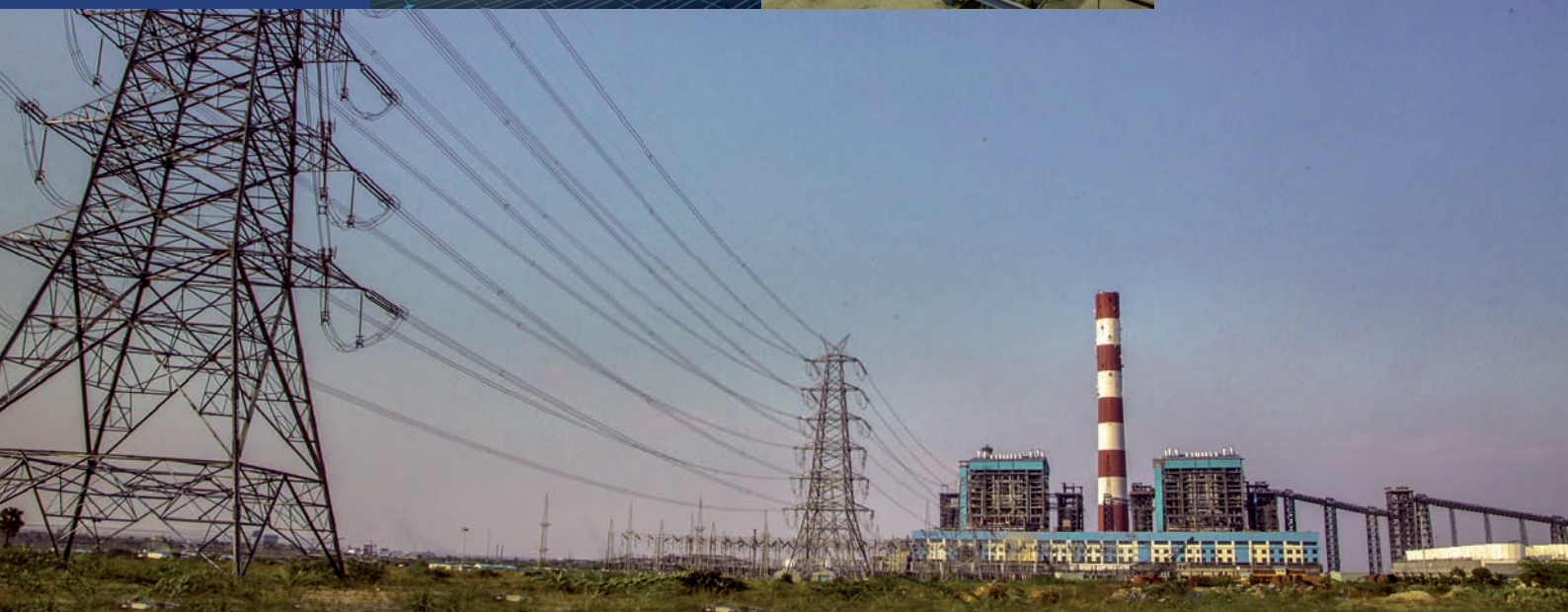
ONE STOP
POWER SOLUTIONS

FIVE DECADES
of **MAKING IN INDIA**



About BHEL

BHEL is a celebration of India's industrial achievements. Established in 1964, it is one of India's largest engineering and manufacturing enterprises in the energy and infrastructure sectors and a leading power equipment manufacturer globally.

BHEL serves the core sectors of the economy and provides a comprehensive portfolio of products, systems and services to customers in power, transmission, transportation, renewables, water, defence & aerospace, oil & gas and industry from its widespread network of 16 manufacturing plants, 2 repair units, 4 regional offices, 8 service centres, 15 regional marketing centres, 3 overseas offices and more than 150 project sites across India and abroad. In all, BHEL has footprints in 83 countries in all the six inhabited continents.

The worldwide installed base of power generating equipment supplied by BHEL exceeds 185 GW- making it the undisputed leader amongst Indian power plant equipment manufacturers. BHEL has installed more than 1000 utility sets in thermal, hydro, nuclear & gas based power plants, contributing 53% to the total installed conventional power generation capacity in the country.

All the entities of the company are accredited to ISO 9001:2015, Quality Management Systems, with major manufacturing units also accredited to Environmental Management Systems, ISO 14001:2015, and Occupational Health & Safety Management Systems, OHSAS 18001:2007.

BHEL's first 700 MW supercritical set at Bellary STPS, Karnataka

BHEL's Contribution to Power Sector

2x363 MW Combined Cycle Power Plant at OTPC- Palatana, Tripura

BHEL is synonymous with the growth of the power sector in the country. BHEL has presence in all the power generation segments comprising thermal, nuclear, hydro, gas and solar. BHEL's first coal-based set was installed at Basin Bridge in Tamil Nadu in 1969. Since then, BHEL has joined an elite club of select global giants by installing a staggering 1,80,000 MW of power generating equipment worldwide.

BHEL has maintained its strong position in the market over the years. Even amidst strong competition from global players in a shrinking market, it has been able to maintain its dominance in the power sector with a healthy share of power plant orders year after year.

Thermal Power

Highest rating 800 MW supercritical thermal set commissioned by BHEL at RPCL Yeramarus, Karnataka

BHEL has proven turnkey capabilities for executing power projects from concept to commissioning. BHEL is capable of executing coal-based power projects on Engineering, Procurement & Construction (EPC) basis for subcritical & supercritical technologies up to 1,000 MW rating.

BHEL also offers state-of-the-art emission control equipment for coal-based plants for lower carbon footprint complying to the revised emission norms notified by the Government of India. BHEL has been supplying Electrostatic Precipitators (ESPs) for control of particulate matter, not only for boilers supplied/ manufactured by BHEL, but also for boilers of other manufacturers. BHEL is the pioneer in domestic manufacture and supply of Flue Gas Desulphurisation (FGD) System for SOx control and is executing a large number of orders for FGD systems for old and new plants. In addition, BHEL is also offering Selective Catalytic Reduction (SCR) system for NOx control for coal-based plants.

BHEL has been in the forefront in installing environmental friendly supercritical coal fired power plants and has secured orders for 53 steam generators (SGs) & 46 turbo-generators (TGs), out of which 15SGs and 13 TGs have been commissioned till 28.02.2018. This is the highest number of supercritical sets ordered on a single manufacturer of the country.

In order to overcome the current uncertainty of coal supply, BHEL has indigenously developed a 'Fuel Flexible Boiler', which is capable of firing the entire range from 100% Indian to 100% imported mix of coal. The design has been developed by BHEL with its vast experience of over five decades of working with various coals. This will provide security against variation in design coal and the coal actually available during operation, thereby offering operational flexibility to customers to ensure uninterrupted generation of electricity.

BHEL also manufactures Circulating Fluidized Bed Combustion (CFBC) boilers that efficiently utilize the low calorific lignite available in India and has commissioned power projects based on CFBC technology up to 250 MW rating.

With an aim to further promote greener use of coal, the company is striving for development of Advanced Ultra Supercritical Technology, which is a pioneering project undertaken jointly by BHEL, NTPC and Indira Gandhi Centre for Atomic Research (IGCAR).

BHEL has also forayed into the electricity generation business with the commencement of commercial operation at 2x800 MW Yeramarus TPS in Karnataka, which has been set up by the joint venture of BHEL and KPCL.

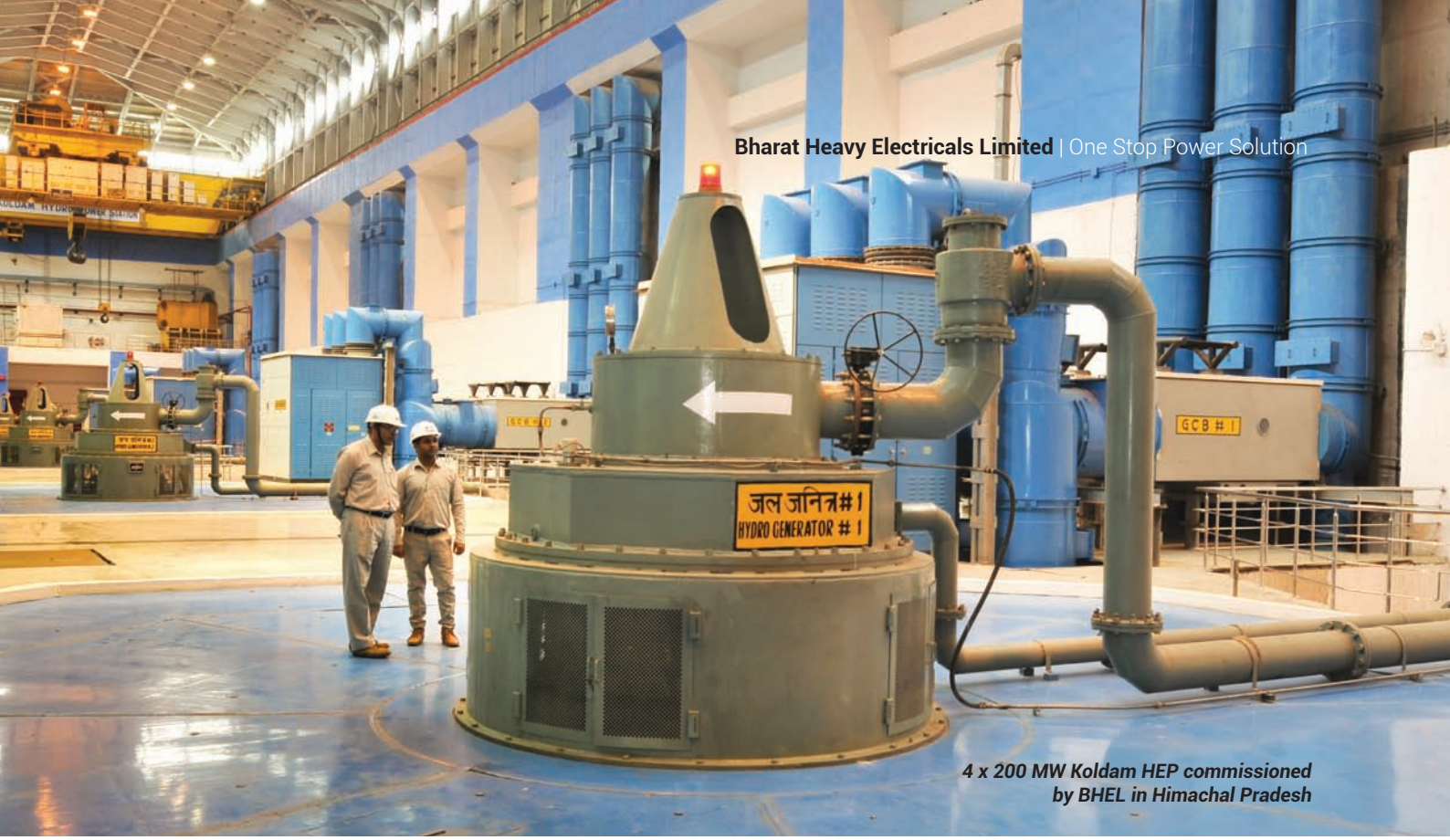
In the gas-based power segment, BHEL offers gas turbines and matching generators ranging upto 299 MW (ISO) rating, tailored to meet specific needs, for both open and combined cycle operation.

Nuclear Power

BHEL is the only Indian company associated with all the three stages of the Indian Nuclear Power Programme (be it 1st Stage PHWR, 2nd Stage FBR or 3rd Stage AHWR) and has been a reliable partner in development of indigenous Nuclear Power Programme since its inception in 1974, i.e., for more than four decades now. The company has dedicated infrastructure and skilled manpower to address to the special design, manufacturing and testing requirements complying with international codes and standards for various components/ equipment of a nuclear power plant. BHEL has proved its capability as a designer and manufacturer of both primary and secondary side equipment for nuclear power projects. Currently, BHEL manufactured Steam Turbine Generator Sets contribute nearly 50% of country's total installed nuclear power capacity of 6.78 GWe.

From the first indigenously-built 220 MWe nuclear set at MAPP, Kalpakkam, to the commissioning of the first 540 MWe nuclear set at Tarapur, BHEL has supplied and installed complete Turbine Island equipment for 12 out of 16 PHWRs developed indigenously. Presently, BHEL is installing Turbine Island equipment for 4 nos. 700 MWe PHWRs. BHEL has also executed the Turbine Island equipment for 2nd stage FBR of 500 MWe rating being constructed at Kalpakkam by BHAVINI. Further, the customer reposed their faith on BHEL for erection and commissioning of Turbine Island for 2x1000 MWe Kudankulam (LWR) nuclear power plant. BHEL today is fully geared to take up and execute the complete TG Island on EPC basis.

Turbine Hall of 2x540 MWe at Tarapur Atomic Power Plant



4 x 200 MW Koldam HEP commissioned by BHEL in Himachal Pradesh

Hydro Power

In the hydro power sector, BHEL has augmented its capabilities to manufacture hydro sets of upto 300 MW unit size. Developing efficient runner profiles and reducing hydro turbine weight have been instrumental in BHEL's recent successes in the field.

BHEL has the capability to deliver complete hydro power plants including design, engineering, supply/ logistics and erection & commissioning. Hydro turbines in the range of 5 MW to 300 MW unit sizes of various impeller types namely Francis, Kaplan and Pelton along with matching generators are designed, engineered, manufactured and tested at BHEL's own manufacturing plants.

Significantly, more than 500 hydroelectric generating sets of various ratings have been ordered on BHEL in India & abroad with a cumulative capacity of more than 29000 MW. Of these, equipment for about 5700 MW generating capacity are for projects overseas. BHEL's hydro plants are successfully and efficiently performing in India and across the world, including at Afghanistan, Azerbaijan, Bhutan, Malaysia, Taiwan, Tajikistan, Rwanda, Thailand, New Zealand, Nepal and Vietnam.

Renewables

BHEL was one of the first companies in the country to foresee the Solar Photo-voltaics (PV) as a major segment of energy portfolio and its entry into the PV business sector has been in line with its commitment to the development and manufacture of various forms of power generation equipment providing clean and green technology for sustainability.

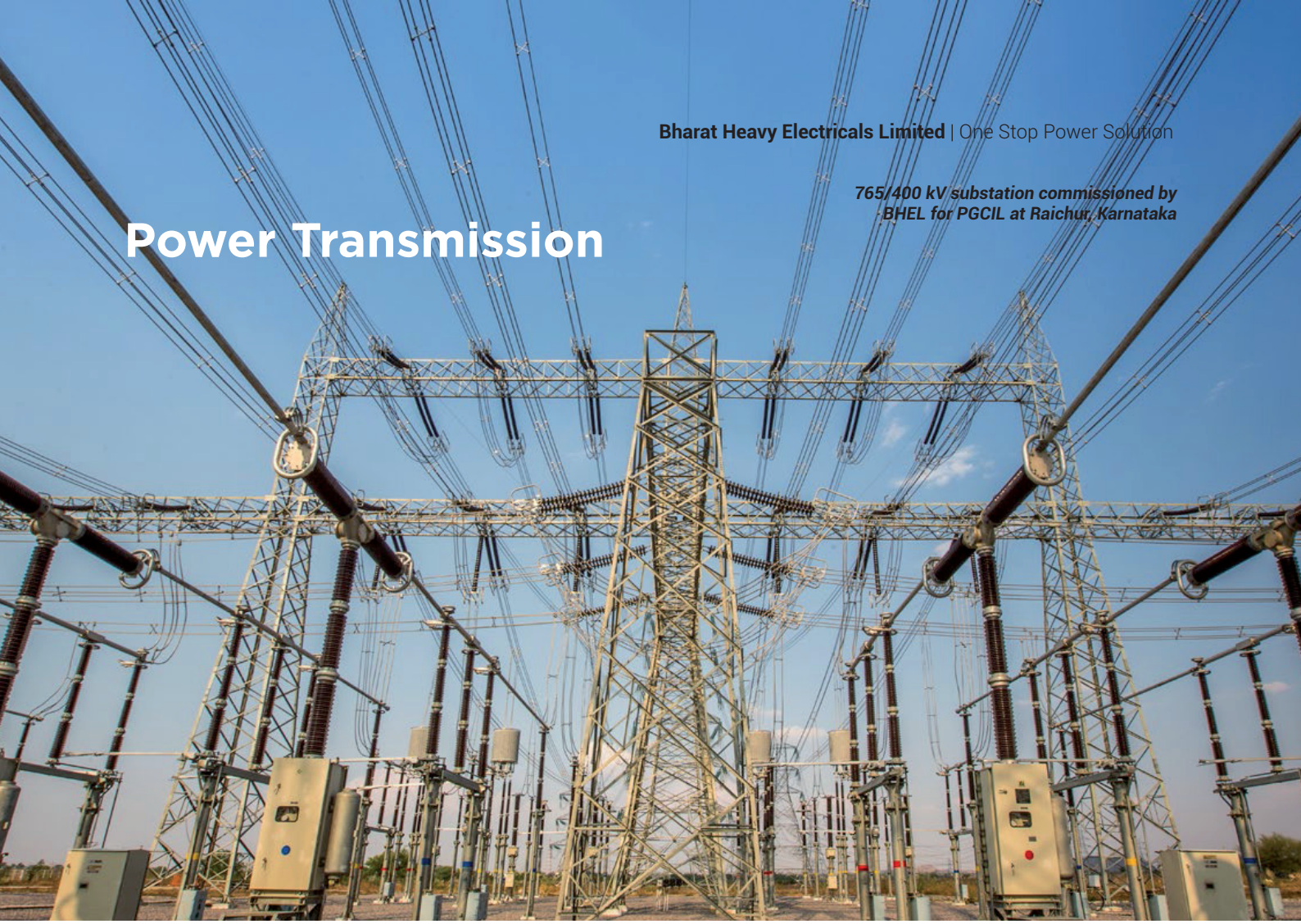
Commencing in the year 1983, BHEL, has been continuously utilizing its in-house expertise and experience in semiconductor technology to process silicon wafers and manufacture cells and modules used in solar PV systems. The efficiency of BHEL manufactured solar cells has reached a level of 19.5 % and module ratings up to 330Wp with complete in-house efforts & development and is at par with the international standards. Solar cells and modules manufactured by the company are regularly characterized and tested by International Solar Energy Research Institutes like ECN (Energy Research Centre Netherlands), ISE Fraunhofer Solar Energy Institute and NREL. Further, BHEL PV Modules have been accorded with International IEC certificates by TUV Rhineland and UL India.

It is notable that BHEL is the only Public Sector Undertaking in the country which has generated indigenous expertise in all critical parts of the silicon value chain (wafer to power plant) through design, supply, commissioning and O&M of solar PV power plants. A dedicated R&D group works in the area of semiconductor materials, Nano and thin film devices at its R&D centres in Hyderabad and Gurugram. Based on its strength in the areas of semiconductor materials and solar photovoltaic experience, ISRO has partnered with BHEL for fabrication of space-grade solar panels and satellite batteries (deployed in all its space programs).

BHEL associated with the Union Territory of Lakshadweep in 1985 to deploy solar power systems of 1.9MW so as to preserve their ecological environment. Since then, several MW-size grid-connected solar PV plants have been designed, installed and commissioned during the last seven years at various locations in the country, including the prestigious NLC 65 MW, NTPC 50 MW Kadiri and NTPC 50 MW Mandsaur. Presently, BHEL's portfolio in solar PV is approx.470MWp out of which about 330 MWp is in operation and 140 MWp is under execution.

BHEL's major customers in Solar PV plants include NTPC Ltd., NLC India Ltd., KPCL, WBSEDCL, Ltd., BEL, HPPCL, IOCL, NEEPCO, Electricity Department – Daman & Diu, ONGC Ltd., DNH Power Development Corporation Ltd., GEDCOL and NREDCAP, to name a few.

1 MW canal top solar PV plant commissioned by BHEL at Bhimavaram, Andhra Pradesh



765/400 kV substation commissioned by BHEL for PGCIL at Raichur, Karnataka

Power Transmission

BHEL is the leader in the field of power transmission in India offering a wide range of transmission systems and products and has a proven track record across the globe. BHEL undertakes turnkey transmission projects from concept to commissioning on EPC basis which includes EHV & UHV substations/ switchyards of both AIS and GIS types ranging from 33 kV to 765 kV, HVDC converter stat ions up to ± 800 kV, Reactive Power Compensation Schemes and Power System Studies.

The products manufactured by BHEL include power transformers, instrument transformers, dry type transformers, shunt reactors, vacuum and SF6 switchgear, gas insulated switchgear, ceramic and composite insulators, etc. Other major critical equipment such as capacitor banks, circuit breakers, control and protection equipment and thyristor valves are also in its manufacturing range.

BHEL has indigenously developed and commercialized Gas Insulated Switchgear (GIS) up to 400 kV and transformers & shunt reactors up to 765 kV. The company also developed & supplied 1200 kV CVT, 1200 kV Auto Transformer and 530 kN porcelain type disc insulators for the first 1200 kV test station in the country. BHEL has a complete range of porcelain and composite type insulators for EHV/UHV (AC/DC) applications.

BHEL has indigenously developed & executed compensation system using FACTS devices like Fixed Series Compensation(FSC) for 400 kV lines and Thyristor Controlled Shunt Reactor (CSR) for dynamic reactive power management of long 400kV transmission lines. For controlling power flow in 400kV systems, BHEL has indigenously developed Phase Shifting Transformer (PST) and commissioned India's first PST at Kothagudem power plant of TSGENCO in Telangana. The PST contributes towards improving the transmission efficiency and also averts grid collapse in case of system instability.

The company has executed a number of High Voltage Direct Current (HVDC) projects in India, notably the world's largest ±800 kV, 6000 MW Ultra High-Voltage Multi-terminal DC transmission link between North Eastern part of India and Agra (Uttar Pradesh). BHEL is also currently executing ±800 kV, 6000 MW, Raigarh-Pugalur HVDC project, which is another milestone project in HVDC segment.

With a wide-spread manufacturing base and a rich experience of four decades in the transmission sector in multiple profiles – EPC contractor, consortium partner and service provider, the company offers a one-stop solutions in all transmission segments.

Water Management

BHEL offers comprehensive, concept to commissioning treatment solutions for various feed water characteristics ranging from pre-treatment to tertiary treatment for power plant, industrial &municipal applications. This includes Pre-Treatment-Sedimentation, Filtration, and RO-based Sea Water Desalination Plant, DM Plant, Effluent Treatment Plant (ETP), Sewage Treatment Plant (STP) and Zero Liquid Discharge (ZLD) system.

The first One Million gallons per day sea water Reverse Osmosis (SWRO) Desalination plant in India for public utility needs was set up by BHEL in Narippayur, Ramanathapuram district, Tamil Nadu in the year 1999. BHEL has executed a number of treatment plants for power plants and one of the largest (96 MLD) Membrane-based Raw Water Treatment Plant for the petrochemical industry at Dahej. Presently, BHEL is executing an order from M/s Raipur Development Authority (RDA) for construction of six decentralised Sewage Treatment Plants (STPs) of cumulative capacity of 25.4 MLD in Raipur, Chhattisgarh.

BHEL also has a dedicated Pollution Control Research Institute (PCRI) and extensive lab facilities to carry out preliminary water characterisation for process design and process optimization at various stages of plant operation and support in performance evaluation of the different treatment plants, assessment of water/effluent/sewage characteristics and water audits etc.

RO membranes of RODM Plant at RPCL Yeramarus, commissioned by BHEL

Service-after-sales

In line with its commitment to complete customer satisfaction, BHEL lays special emphasis on after sales service. Prompt and efficient handling of customers' concerns is an assurance that accompanies BHEL's involvement in any project.

BHEL has eight organized service centres operating from different parts of the country. Troubleshooting/ overhauling/ repairs are routine services offered by BHEL.

A dedicated Spares & Services Business Group (SSBG) has been set up to provide a single-window facility to customers for all post warranty solutions be it spares, services or R&M/ uprating requirements of power plants both in utility and the captive power segments.

BHEL has also developed the expertise to undertake Renovation, Modernization and Uprating of old power plants and Life Extension Programme (LEP) for aging sets. Converting PF coal-fired old boilers into FBC type, changing blade profile in turbines and switching from micalastic/ H-type insulation to F/green-type insulation in electrical machines are a part of R&M and LEP resulting in enhanced efficiency of the respective products as well as the power plant as a whole.

Other benefits of R&M/uprating include:

- Life extension of the plant by 15-20 years
- Restoration of lost capacity and/or enhancement of rated capacity
- Increase in safety, reliability, availability and operational flexibility
- Improvement in aux power consumption, plant heat rate, plant emission level, etc.
- Introduction of state-of-the-art systems/ technologies for better O&M practices
- Optimizing cost of generation
- Compliance to statutory pollution norms

BHEL ensures timely availability of spares and also provides special training to customers' O&M personnel.

For enquiries & further information

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