Vol 65 No 12 December 2025 ₹400

Since 1961

Electrical India

ISSN 0972-3277

India's oldest magazine on power and electrical products industry

65 YEARS OF SERVICE TO THE INDUSTRY

CERTIFIED ISO 9001:2015 14001:2015 45001:2018 COMPANY

DEK & MAVERICKS GREEN ENERGY LIMITED

COMMITTED TO BUILD A SUSTAINABLE FUTURE

350+	5+	550+	150+	100+
MWp SOLAR EXECUTED	YEARS IN SOLAR EPC	MWp UNDER EXECUTION	MANPOWER COUNT	SITES LOCATION

As an EPC company, DEK & Mavericks Green Energy Limited is promoting the use of clean energy in every industry by powering large solar farms, providing customised commercial solutions, and empowering homes with rooftop systems. Our experience guarantees dependable, effective, and sustainable power for households, businesses, and industries.

GEARED UP TO EXPAND UPTO 12+ STATES

OUR CAPABILITIES AS AN EPC COMPANY

- Engineering
- Procurement
- Installation
- Testing
- Commissioning
- Liasoning
- Operations & Maintenance

OUR SERVICES

EPC for Ground Mount Solar

Commercial / Industrial Rooftop Solar

Residential Rooftop Solar

SINGLE LARGEST PROJECT OF 120 MWp.

DEK & MAVERICKS GREEN ENERGY LIMITED

903 B-Block, UNICUS SHYAMAL, Shyamal Cross Road, Ahmedabad – 380015.

+91 80554 99000, +91 90990 38840, +91 99250 00395 | sales@dmgel.in | www.dmgel.com, www.dmgel.in

Vol 65 No 12 December 2025 ₹400

Since 1961

Electrical India

ISSN 0972-3277

India's oldest magazine on power and electrical products industry

65 YEARS OF SERVICE TO THE INDUSTRY

SYNCHRONOUS CONDENSERS FOR A RELIABLE GRID

Maintaining grid reliability is becoming increasingly challenging due to evolving regulatory requirements and the shift toward a cleaner, more diversified energy mix. These changes present new complexities for electricity grid operators who are responsible for ensuring a stable energy supply.

ANDRITZ Synchronous Condensers offer a reliable, proven, cost-effective, and intelligent solution to meet these demands. Whether for greenfield installations, modernization, or uprating projects, ANDRITZ delivers top-tier solutions across a broad portfolio of standardized Synchronous Condenser systems.

In India, ANDRITZ leverages its two state-of-the-art manufacturing facilities in Mandideep and Prithla to provide cutting-edge technology that enhances grid stability and supports the country's energy transition.

ANDRITZ HYDRO PRIVATE LIMITED /
A-24/3, Mohan Cooperative Industrial Estate, Mathura Road / 110044, New Delhi, India
p: +91 11 49372900 / e: contact-hydro.in@andritz.com / www.andritz.com/hydro-in

ANDRITZ

(A TE-Connectivity - RPG Enterprises JV)

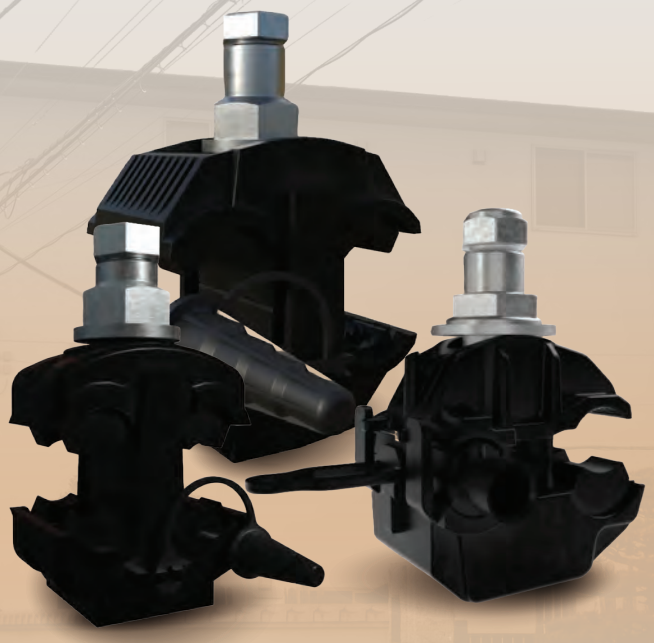
Raychem RPG

Global Experts for AB Cable Accessories

Theft Proof, Safe and Reliable Accessories for AT&C Loss Reduction

Insulation Piercing Connector (IPC)

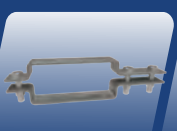
- Tested as per NFC 033-020 standard
- Precision torque shear-head bolts for consistent contact
- Made of weather and UV resistant glass fiber reinforced polymer
- No conductor stripping required, faster & safer installation

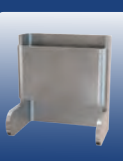


Anchoring Clamp

Suspension Clamp

Other Accessories





Product Offerings

- Cable Accessories
- Cable Management Solutions
- ABC Accessories
- Enclosures
- Transformers
- Covered Conductors
- Surge Arrester
- Electrical Safety
- Gas Metering Solutions
- ELPS
- Solar Products
- EV & BESS Bus Bars

www.raychemrpg.com
CIC@raychemrpg.com
022 4574 5060

From the Publisher's Desk

How will India fare during the Upcoming radical global transition?

In 2026, the face of global electricity generation will be defined by the ascendancy of renewables. This shift will be driven by massive expansions in wind and solar power, leading to a decline in the share of fossil fuels and a plateauing of power sector emissions.

With this backdrop, naturally the question that comes up is how well prepared is India to be a part of the emerging world at the beginning of the new year 2026? Let us have a look at our preparation at the end of 2025.

At present, India's power market is the world's fifth-largest by generation, naturally being on a leading position, it has to play a big role at this phase of unprecedented transition.

As of today, our power sector is highly advanced due to its rapid renewable energy growth – hitting 50% non-fossil capacity ahead of schedule, achieving near-universal household electrification, developing one of the world's largest single grids with high-voltage lines, adopting smart grid tech, and balancing surging demand with diversification, making us a leader in the global energy transition.

Let me now delve a bit more. We add huge renewable capacity annually (e.g., 24.5 GW solar in 2024), driving down costs and integrating green energy into our diversified mix. We already have one of the world's most diverse power sources, combining renewables with traditional coal, gas, hydro, and nuclear, while integrating advanced technologies like bifacial solar modules and agrophotovoltaics. Our heavy investment has already established grid strength and reliability. Initiatives like PM-KUSUM and smart grid development demonstrate visionary policy and technological adoption for sustainable growth. Won't we be at the forefront of this radical global transition?

Mahadevan

Publisher & Editor-In-Chief

Directors
Pravita Iyer
Mahadevan Iyer

Publisher & Editor-In-Chief
Mahadevan Iyer
miyer@charypublications.in

Director Commercial
Pravita Iyer
pravita@charypublications.in

Editorial Department
P. K. Chatterjee (PK)
pkchatterjee@charypublications.in

Gijeesh Nair
edit@charypublications.in

Advertising Department
Nafisa Khan
advt@charypublications.in

Jasoda Adal
advt-electricalindia@charymedia.in

Design
Sachin Parbalkar

Subscription Department
Nafisa Khan
sub@charypublications.in

Accounts Department
Dattakumar Barge
accounts@charypublications.in

Follow us on:

electricalindiamagazine
electricalindia
ElectricalIndia
electricalindia1961

Chary Publications Pvt. Ltd.
1008, The Corporate Park,
Plot 14 & 15, Sector 18, Vashi,
Navi Mumbai 400703
Phone: 022 4961 2499
www.electricalindia.in

Single Issue: ₹ 400 / Annual Subscription: ₹ 4000

Printed, Published and owned by Mahadevan Iyer from 1008, The Corporate Park, Plot 14 & 15, Sector 18, Vashi, Navi Mumbai 400703 and Printed at Print Tech., C-18, Royal Indl Estate, Naigaum Cross Road, Wadala, Mumbai - 400 031. Editor: Mahadevan Iyer

HPL

EMPOWERING INDIA FOR A SMART FUTURE

India's leading electric equipment manufacturer with highly efficient manufacturing facilities integrated with research and development centers, offering world class range of products to facilitate the consumers with best in class technology and innovative solutions.


Switchgear


Metering


MCB & DB


Fan


LED Lighting


Modular Switch


Solar


Wires & Cables

hpl@hplindia.com,
Customer Care No.1800 419 0198
www.hplindia.com

Follow us :

buildelec | compelec
A unique component sourcing show

Visit us at:
Stall No. BC7 | 25th, 26th & 27th February 2026
Bombay Exhibition Centre, Mumbai

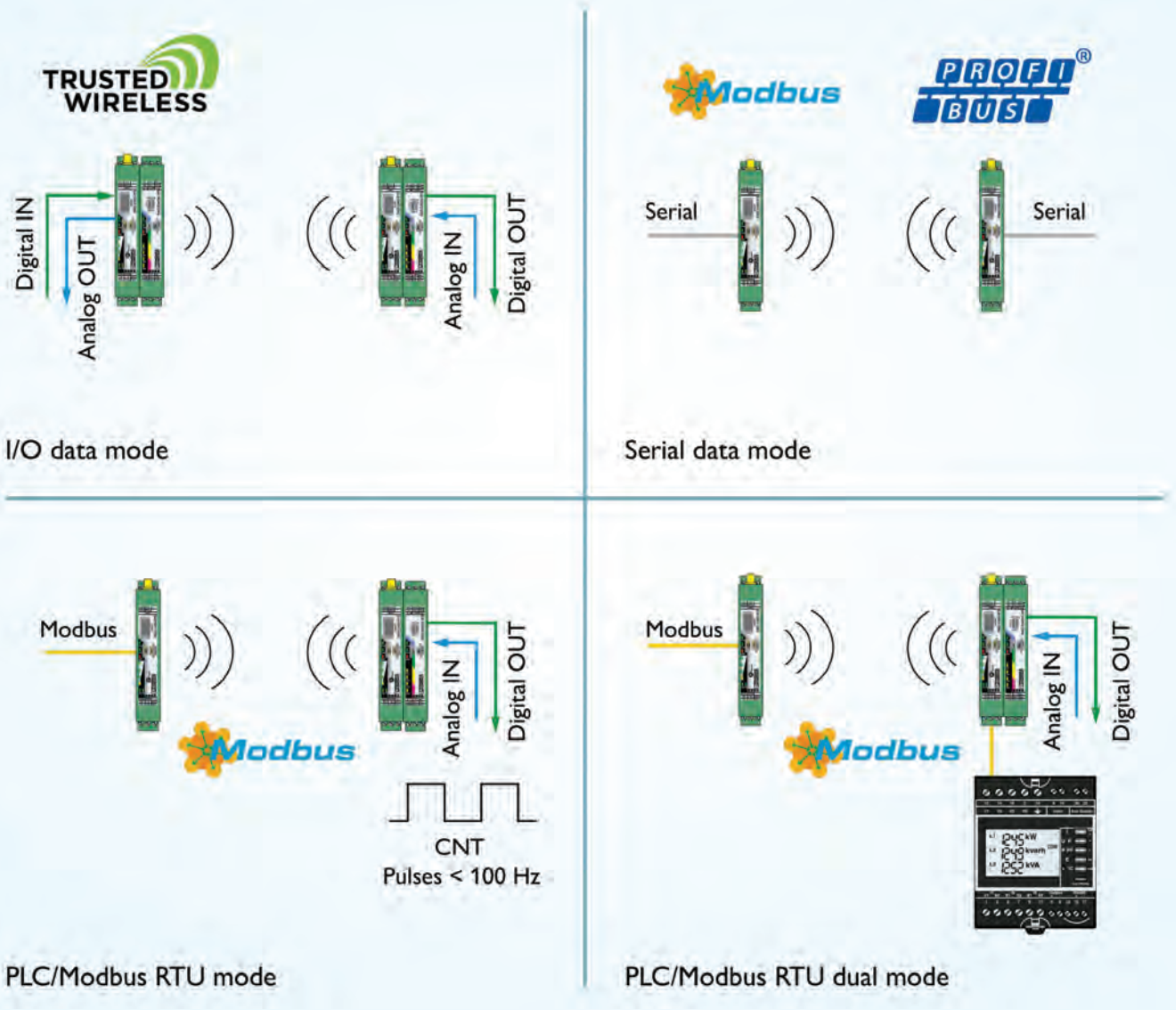
Electrical India

Contents

Vol. 65 | No. 12 | December 2025

ANNUAL 2025

www.electricalindia.in



Industrial wireless: Trusted wireless 2.0 Radio line for material handling

Year by year, more wireless technologies are used in automation technology. Users benefit from this, as wireless solutions offer a higher degree of mobility and flexibility. Often it is the cost saving from the elimination of cable installation which is the reason for the use of a wireless system. Works on licence free band of 2.4Ghz.
Trusted Wireless 2.0 is a wireless technology developed specially for industrial use. It is particularly suitable for sensor-actuator information covering cable infrastructure is from one. It is used to up small to medium-sized data quantities, over larger distances of hundreds of meters to several kilometres.

PHOENIX CONTACT
INSPIRING INNOVATIONS

HEAD OFFICE
Phoenix Contact (India) Pvt.Ltd.
F-26/2, Okhla Industrial Area, Phase-II,
New Delhi - 110 020 INDIA
Tel.: +91-11-71810700 / 800
Fax: +91-11-41611071
E-mail: response@phoenixcontact.co.in
Website : www.phoenixcontact.co.in

SOUTHERN INDIA OFFICE
No. 10/7 - 8, 2nd Floor,
Umiya Landmark, Lavelle Road,
Bangalore - 560 001
Tel.: +91-80-33235400

WESTERN INDIA OFFICES
30, Shaswat Bungalow, 1st Floor,
Ceaser Road, Amboli,
Andheri [W], Mumbai - 400 058
Tel.: +91-8377004752 / 4753

5th Floor, Devi House,
37, Shivaji Nagar,
Pune - 411 005
Tel.: +91-20-71395000-031

Contents

ANNUAL 2025

Interview
Vinay Rathi, Director, Gloster Cables Limited (GCL)

Electric Vehicles
Honda's Plans for the Second Half of 2020s

Solar Bicycles
Addressing the Triple Planetary Crisis

Next-Generation Cars
Battery Electric Vehicles

Efficiency
Control Panels in the Indian Power Sector

Safety
Different Low Voltage Earthing & Bonding Systems

REGULARS

JINDAL

Jindal Aluminium

inspire possibilities

INDIA'S LARGEST ALUMINIUM EXTRUSION COMPANY

- 55+ Years of legacy
- Turnover of approx. INR 5,500 crore
- Global clientele spread across 55+ countries
- Manufacturing units at Bengaluru, Dabaspet, and Bhiwadi
- Total installed production capacity of 2,55,000 MTPA
- 100+ Dealers in India

We use **100%** renewable energy for manufacturing @ Bengaluru and Dabaspet units

Iconic Brand of India, 2023 | Brand of the year, 2024

ISO 9001:2015 | ISO 14001:2015 | ISO 45001:2018 | PED by HSB Global Standards, UK | NVT QC | ANAB ACCREDITED | Nadcap Administered by PRI

Know More

+91 9900-072-169

Hello@JindalAluminium.com

Since 1968

AI, Machine Learning to Transform India's Power Sector

The conference, involved a national call for innovation...

While addressing the participants in the Two-day National Conference focusing on the use of AI/ML technologies in the power distribution sector, at Bharat Mandapam, New Delhi, Minister of Power, Manohar Lal said that Artificial Intelligence (AI)- and Machine Learning (ML)-based applications will play a pivotal role in building intelligent, consumer-centric, self optimising distribution networks.

He noted that the AI/ML based solutions, smart meter analytics, digital twins, predictive maintenance, theft detection intelligence, appliance-level consumer insights, automated outage prediction and GenAI-based decision support can transform both consumer experience and operational efficiency.

Lal lauded the active participation of industry, states, innovators, academia, and technology partners at the National Conference. He appreciated the AI/ML solutions presented by Distribution Companies (DISCOMs), Advanced Metering Infrastructure Service Providers (AMISPs), Technology Solution Providers (TSPs) and Home Automation Solution Providers (HASPs).

The Minister urged all DISCOMs to work closely with ecosystem stakeholders to transition towards smart, reliable, and consumer-focused distribution systems. He remarked that there was also a need to actively engage consumers. It is important to remove misinformation that sometimes surrounds new technologies and to win the valuable support of consumers for technology adoption in the sector.

The minister noted that the AI/ML based solutions highlight a powerful narrative of technology restoring trust, empowering households to manage their consumption better, preventing outages before they occur, protecting honest consumers from theft burdens and enabling DISCOMs to reduce losses, optimise power purchase costs and reinvest in stronger infrastructure – positioning India as a global leader in digital electricity reform and future-ready grid governance. EI

Government's Efforts to Reduce Carbon Emission

In order to reduce carbon emissions and environmental impact of coal-based thermal power generation, Indian government has taken some major steps.

The Ministry of Power is promoting installation of efficient Supercritical or Ultra Supercritical units that are more efficient and leading to reduced CO_2 emission per unit of electricity generation. A total capacity of Supercritical or Ultra-supercritical units of 70,190 MW (101 Units) and 7,680 MW (11 units) have been commissioned respectively till 31.10.2025.

To improve the energy efficiency, the Perform Achieve and Trade (PAT) scheme has been implemented in various thermal power plants.

Ministry of Power has issued a comprehensive policy on 07.11.2025 for co-firing of bio-mass pellets [including torrefied charcoal made from Municipal Solid Waste (MSW)] in Coal Based Power Plants to use 5-7% blend of biomass pellets and/or MSW-based torrefied charcoal along with coal, after assessing the technical feasibility.

MoEF&CC vide notification dated 07.12.2015 and its subsequent amendments has notified norms in respect of reducing stack emissions such as Suspended Particulate Matter (SPM), Sox & NOx from coal based thermal power plants. To meet these standards, Thermal Power Plants are using techniques like ElectroStatic Precipitator (ESP), Flue Gas Desulphurization (FGD), NOx Combustion Modification etc. EI

India Has Installed 4.76 Crore Smart Meters

Under Revamped Distribution Sector Scheme (RDSS), 20.33 crore smart meters have been sanctioned based on the proposal submitted by the states. In addition, many states have installed smart meters under the state schemes or externally aided projects. Till date 4.76 crore smart meters have been installed in the country under various schemes.

Under RDSS, smart metering is being carried out through Public Private Partnership (PPP) in TOTEX (i.e., total expenditure, which is sum of capital expenditure and operational expenditure) mode. The Advanced Metering Infrastructure Service Provider (AMISP) is responsible for supplying, maintaining and operating the metering infrastructure post installation.

To promote indigenisation in smart meters, MoP, after deliberations with stakeholders, has taken various steps including: the minimum local content in smart meters is to be 60%. In July 2023 smart meters were included in the Annexure I of Public Procurement (Preference to Make in India), Order. EI

Key Initiatives to Bring Down AT&C Losses

Government of India has been supporting the power distribution utilities to improve their Aggregate Technical and Commercial (AT&C) losses through various initiatives.

Revamped Distribution Sector Scheme (RDSS) launched with the objective of improving the quality and reliability of power through a financially sustainable and operationally efficient Distribution Sector. The scheme aims at bringing down the AT&C losses to pan-India level of 12-15% and ACS-ARR gap to zero.

Under the Scheme, projects worth Rs. 2.83 lakh crore have been sanctioned. These involve distribution infrastructure works worth Rs. 1.53 lakh crore that include replacement of old/frayed conductors, laying Low Tension Aerial Bunched (LT AB) cables, and upgradation/augmentation of Distribution Transformers (DT)/Sub-stations, agriculture feeder segregation etc.

The fund release under the scheme has been linked to performance of distribution utilities against various financial parameters, the prominent among them being AT&C losses and ACS-ARR Gap. Execution of these works would also help improve quality of supply of power. Prepaid smart metering is also one of the critical interventions envisaged under RDSS, which would help in improving AT&C losses. EI

CENTRAL POWER RESEARCH INSTITUTE (CPRI)

Since 1960

Over Six Decades of Dedicated Services to Power Sector

Inauguration of CPRI's new regional testing laboratory at Nashik

CPRI has established its new regional unit at Nashik on 10th Sep 2025. Shri Manohar Lal Khattar, Honourable Minister of Power and Minister of Housing & Urban Affairs, Government of India along with Shri Devendra Fadnavis, Honourable Chief Minister of Maharashtra, inaugurated the CPRI unit at Nashik.

Test facility at CPRI Nashik:

- 1500 MVA On Line Short Circuit Testing Laboratory – Transformers up to 10 MVA 33 kV class (HV).
- Routine & Temperature Rise Test facility - Transformers up to 10 MVA 33 kV class (HV)
- Impulse Voltage test facility for 800kV, 80 KJ - Transformers up to 10 MVA 33 kV class (HV) and other equipment up to 132 kV
- Energy Meter Test Laboratory - Type and Acceptance test on conventional and smart energy Meters
- EMI/EMC Laboratory - Type test on conventional and smart energy Meters and Other equipment- up to 200 A

Activities of CPRI:

- Testing & Certification of Power Equipment
- Applied Research in Electrical Power Engineering
- Consultancy and Field-testing services to Power Utilities & Industry
- Third Party Inspection and Specialized Training Programs

Accreditations:

- ISO/IEC 17065: Accredited by NABCB.
- ISO/IEC 17025: Accredited by NABL
- ISO 9001: 2015 Research and Consultancy Activities
- Bureau of Indian Standards (BIS)

Credentials:

- Member of the Short Circuit Testing Liaison (STL).
- Member of DLMS User Association
- UL, CSA & CB Certification
- UCA International Users Group
- Approved by EDD, Kingdom of Bahrain

Test facilities at CPRI laboratories:

- Testing of Transformers/Switchgear etc.,
- Power Cable & Accessories and Capacitors
- Insulators and Lightning Arresters
- Transmission line Tower, Conductors & Accessories
- Vibration Studies & Seismic qualification
- Smart Meters, Energy Meters and Relays
- Cybersecurity of IEDs & RTUs.
- EV Batteries, EV chargers, Solar Inverters
- Refrigerators and Air Conditioners
- Material characterization including CRGO, Transformer oil
- Domestic appliances including LED and SPV Lighting Systems

cprimop CPRIWoP

केंद्रीय विद्युत अनुसंधान संस्थान

Central Power Research Institute

(A Government of India Institute, Ministry of Power)

Prof. Sir C.V. Raman Road, Post Box No: 8066, Sadashiva Nagar, Bengaluru – 560080

Visit: www.cpri.res.in ; +91 80 - 2207 2229/2016/2230; enquiry@cpri.in

India Is a Key Driver of the Global Renewable Energy Surge

A view of inauguration of the Global Energy Leaders' Summit 2025...

Highlighting India's historic clean energy expansion, Union Minister of New and Renewable Energy Pralhad Joshi said that India has recorded its highest-ever addition of non-fossil capacity in the current financial year at 31.25 GW, including 24.28 GW of solar. Speaking at the Global Energy Leaders' Summit 2025 in Puri, Odisha, the minister also announced a 1.5 lakh rooftop solar ULA model for Odisha, designed to benefit and empower 7-8 lakh people across the state.

After taking nearly 70 years to reach 1 TW of renewable energy capacity in 2022, the world achieved 2 TW by 2024, adding the second terawatt in just two years, the minister said. India is a key driver of this explosive global surge in renewable energy. In the last 11 years, the country's solar capacity has grown from 2.8 GW to around 130 GW, a rise of more than 4,500%. Between 2022 and 2024 alone, India contributed 46 GW to global solar additions, becoming the third-largest contributor.

The minister noted that India holds the world's fifth-largest coal reserves and is the second-largest consumer of coal. He said that even with this abundance, India is steadily balancing coal with renewable energy as the transition gathers pace. With global mechanisms now shaping industrial competitiveness, he said India's shift towards renewable energy has become even more urgent and strategically important.

Highlighting major new initiatives for Odisha, the Minister announced the approval of a consumer-owned Utility-Led Aggregation (ULA) model under PM Surya Ghar for installing 1.5 lakh rooftop solar systems of 1 kW each in the state. This will benefit nearly 7-8 lakhs of people, especially from economically weaker households in Odisha.

Joshi noted that Odisha is already demonstrating strong clean energy adoption. With over 3.1 GW of installed renewable capacity, clean energy now accounts for more than 34% of the state's total installed power capacity. EI

Government Boosts RE Ecosystem with Green H_2

The Government of India is implementing the National Green Hydrogen Mission (NGHM), with an outlay of ₹19,744 crore to make India a global hub for production, usage and export of green hydrogen.

Till November 2025: i) Under the incentive scheme for Green Hydrogen production, 18 companies have been awarded a cumulative production capacity of 8,62,000 tonnes per annum; ii) Under the incentive scheme for Electrolyser Manufacturing, 15 companies have been awarded a total manufacturing capacity of 3,000 MW per annum; iii) Under the incentive scheme for procurement of Green Hydrogen for refineries, 2 companies have been awarded a total capacity of 20,000 tonnes per annum; and iv) Pilot projects for use of Green Hydrogen in steel, shipping, and transport sectors have been sanctioned.

The Government of India is already implementing various schemes such as the Pradhan Mantri Surya Ghar: Muft Bijli Yojana (PMSG: MBY); Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM KUSUM); and the New Solar Power Scheme for Tribal and Particularly Vulnerable Tribal Groups (PVTG) Habitations/Villages under Pradhan Mantri Janjati Adivasi Nyaya Maha Abhiyan (PM JANMAN) & Dharti Aaba Janjatiya Gram Utkarsh Abhiyan (DAJGUA), along with other programmes. These schemes collectively support the rapid deployment of solar energy based mini grids and rooftop solar projects across the country, including in rural areas, by providing financial assistance. EI

Reason Behind Revocation of GRID Access Permissions Clarified

Since 2022, Central Transmission Utility of India Limited (CTUIL) has revoked connectivity of 24 grantees with a RE capacity of 6,343 MW. The cancellations are on account of developer delays and not due to transmission side delays.

There are sixteen petitions pending before the Central Electricity Regulatory Commission that pertain to cases where the Petitioners (Power Generators) have approached CERC seeking protection from revocation of connectivity.

The Government of India has set a goal of 500 GW of non-fossil fuel-based generation capacity by 2030. Already 259 GW of non-fossil capacity is connected to the grid.

Further, Inter-State Transmission System (ISTS) for evacuation of 172 GW of renewable energy is already under construction, and bids are in process for 19 GW capacity. Simultaneously, the Government of India is working with the States to ensure timely development of respective Intra-State Transmission Systems for evacuation of 152 GW of renewable energy. EI

Framework Established for Industrial Sector Decarbonisation

The framework for the Indian Carbon Market under the Carbon Credit Trading Scheme (CCTS) has been formulated. The institutional structure comprises a National Steering Committee co-chaired by the Secretaries of the Ministry of Power and the Ministry of Environment, Forest and Climate Change, with Grid India functioning as the Registry and the Bureau of Energy Efficiency (BEE) serving as the Administrator.

The CCTS operates through two mechanisms: i) The Compliance Mechanism and the Offset Mechanism. Under the Compliance Mechanism, emission-intensive industries designated as Obligated Entities are required to meet assigned Greenhouse Gas Emission Intensity (GEI) targets, and entities that outperform their targets are eligible for Carbon Credit Certificates; ii) Under the Offset Mechanism, Non-Obligated Entities may voluntarily register projects that reduce, remove or avoid greenhouse gas emissions for the purpose of seeking issuance of Carbon Credit Certificates.

Thermal power plants have not been transitioned from the PAT scheme to the CCTS Compliance Mechanism. EI

iE 250

Versatile and modular intelligent energy controller

The iE 250 controller empowers you to design future-proof intelligent energy solutions with next-level user friendliness, modular flexibility, secure connectivity, and great processing power.

Offering an extensive range of control, protection, and supervision features, it is incredibly easy to use for designers, installers, and operators alike.

Cyber security conforms to IEC 62443 and protects your controller from unwanted access.

DEIF Improve Tomorrow

Ingka Investments Makes its Maiden Renewable Energy Investment in India

IKEA solar farm (scaled)...

Ingka Investments, as a part of its INR 10 billion (EUR 97.5 million) renewable energy commitment to India, has launched a 210 MWp solar installation in Bikaner, Rajasthan, making it the company's first renewable investment in the country.

Ingka Investments, the investment arm of Ingka Group, the largest IKEA retailer, has made a 100% stake investment in a subsidy-free 210 MWp solar project located in Rajasthan, India. The solar project has reached ready-to-build status, and construction will start shortly. Start of operations is scheduled in December 2026. The total expected production is 380 GWh per year.

The investment is a part of the EUR 7.5 billion the company has committed to supporting 100% renewable energy consumption across the value chain and beyond by 2030. Ingka Investments has so far invested and committed EUR 4.2 billion into renewable energy projects in wind and solar energy worldwide.

In India, the company is working with ib vogt, an integrated large-scale solar PV developer headquartered in Germany with a strong presence in India. ib vogt Solar India will also be the partner for construction, and the first three years of operations.

Detailing further, Patrik Antoni, CEO, IKEA India, said, "At IKEA, sustainability is at the heart of everything we do. Over the past eight years, we've invested in making our retail journey more sustainable. Designed with energy efficiency at the core, two of our large-format stores in Bangalore and Navi Mumbai are LEED Gold certified, and we are working towards Platinum certification in Gurugram and Noida. As a founding member of RE100, we are on track to power our operations with 100% renewable energy by 2025. We're also proud of our 100% zero-emission EV deliveries in key cities and are committed to expanding this across all future markets. With EV charging stations in our stores and energy-saving solutions for our customers, and now also an investment in a solar project, we're inspiring positive change and contributing to a cleaner, more sustainable future for India."

Reliance NU Energies Receives LOA

Reliance Power Limited's wholly-owned subsidiary, Reliance NU Energies Private Limited, has received the Letter of Award (LOA) on November 10, 2025 – and has emerged as the largest winner in the first-of-its-kind 1500 MW / 6000 MWh Firm and Dispatchable Renewable Energy (FDRE) ISTS tender issued by SJVN Limited, a leading Navratna enterprise.

Reliance NU Energies secured a capacity of 750 MW / 3,000 MWh, representing the largest single share of allocation under the tender.

The landmark FDRE tender marks a major step towards enabling round-the-clock renewable power supply through hybrid and storage-based energy solutions. The online auction witnessed strong industry participation, being oversubscribed 3.3 times, with 14 bidders qualifying for the reverse online auction process.

With this milestone, the Reliance Group has consolidated its position as India's largest player in the Solar + BESS segment, with a cumulative portfolio exceeding 4 GWp of solar and 6.5 GWh of BESS across 4 tenders, under development and implementation. This achievement, accomplished in just 10 months, highlights the Group's rapid execution capabilities and its commitment to India's energy transition and decarbonisation goals.

The project will supply dispatchable renewable peaking power to DISCOMs from a hybrid configuration comprising nearly 900 MWp of solar generation coupled with over 3,000 MWh of BESS capacity.

ReNew to Invest ~INR 82,000 Crore in Andhra Pradesh

The MoUs were signed in the presence of Nara Chandrababu Naidu, CM; and Nara Lokesh, Minister for IT, Electronics & Communications of Andhra Pradesh...

ReNew Energy Global Plc (ReNew) will invest ~INR 60,000 crore in Andhra Pradesh to set up multiple green energy projects in the state, taking its total fresh investment in the state to ~INR 82,000 crore. The company has already committed ~ INR 22,000 crore to the state in May 2025 to set up one of India's largest hybrid renewable energy projects.

In four separate MoUs signed with the Andhra Pradesh Economic Development Board, the company has announced plans to invest in establishing a 6 GW PV ingot-wafer plant, a 2 GW pumped hydro project, a 300 KTPA green ammonia facility and 5 GW of hybrid projects, including wind–solar and solar–BESS initiatives, in the state.

Tata Power, DGPC Sign Commercial Agreements

From this project, 80% of power will flow to India, however, it will also support Bhutan's energy security...

The Tata Power Company Limited (Tata Power) has signed commercial agreements with Druk Green Power Corporation Limited (DGPC) for the implementation of the 1,125 MW Dorjilung project. The Project will be implemented through a Special Purpose Vehicle (SPV), with DGPC and Tata Power holding equity shares of 60% and 40%, respectively.

The Run-of-the-River project, comprising six units of 187.5 MW each, is being developed on the Kurichhu River in Mongar, Bhutan. Designed with a six-hour pondage for peaking, Dorjilung represents a major step forward in expanding clean, reliable hydropower in the region. Tata Power has committed an equity investment of approximately ₹1,572 crore to be infused in tranches as per the agreed structure.

APAR
Tomorrow's solutions today

WITNESS THE POWER OF APAR

#1 Largest manufacturer in India for special application cables

140+ Countries receive our export products

66 Years of excellence

15 Certificates of compliance with **77** cable types for US markets

5 Electron beam facilities

APAR CABLE PRODUCT RANGE

SPECIALITY PRODUCTS & SERVICES

- Hybrid Cables with Fibre Optic & Coaxial
- Tether, Tactical, Torpedo Cables
- TOW, ROV Cables
- Harness: Locomotives, Solar & Automotive and EV

XLPE ELECTRICAL CABLES

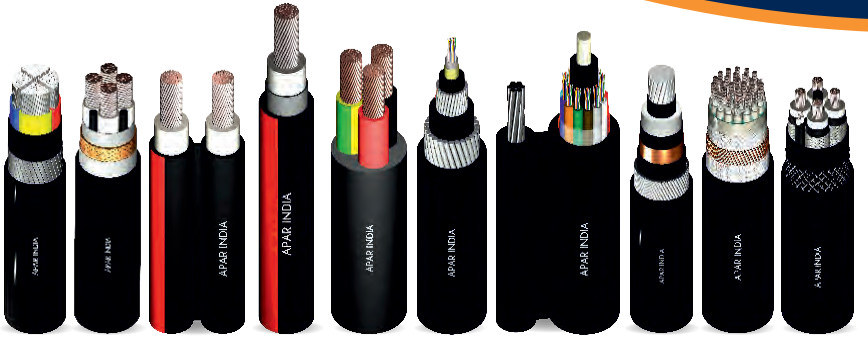
- XLPE Power Cables up to 66kV & 1000 sq.mm
- Medium Voltage Covered Conductors (MVCC)
- LT & HT ABC Cables
- UL Cables (PV/XHWW/URT)

ELASTOMER & E-BEAM CABLES

- Ship & Submarine Wiring Cables
- Wind Mill Cables up to 33 KV
- Solar Cables as per TuV/EN/IEC/UL Specs
- Mining, Welding, Trailing Cables

OPTIC FIBRE CABLES

- Unitube & Multitube Cables
- Tight Buffer & Breakout Cables
- FTTH Cables
- Fire-resistant/Survival Optic Fibre Cables



For more information, write to us at corporate@apar.com

@aparldc | @APARCableSolutions | @aparcablesolutions | @AparLdc | @APARLightDutyCablesWires

www.apar.com I www.aparwiresandcables.com

Signify Opens Philips Smart Light Hub in Ahmedabad, Gujarat


A view of the latest Philips Smart Light Hub in Ahmedabad...

Signify (Euronext: LIGHT) has launched its Philips Smart Light Hub (SLH) in Ahmedabad, Gujarat. Spanning an impressive 2,500 square feet, one of the largest Philips Smart Light Hubs in the western region. The store features a vast selection of over 380 SKUs, offering a holistic shopping experience to customers.

The store's state-of-the-art architecture has been thoughtfully designed to create a dark-room experience, allowing customers to explore the latest innovations in home lighting technology firsthand. This landmark store aims to provide an unmatched home lighting experience for homeowners, interior designers, and architects alike. Featuring a curated range of decorative lighting, functional fixtures, and smart lighting solutions, the store enables customers to explore the latest innovations in lighting technology.

Commenting on the store launch, C Arun Kumar, Head of Consumer Business, Signify Greater India, said, "The launch of our latest Philips Smart Light Hub in Ahmedabad marks another significant step in our journey to make innovative, energy-efficient lighting solutions more accessible to customers across India. Ahmedabad continues to be a key market for us, with consumers who appreciate both functionality and design in their living spaces. Through this new hub, we aim to offer an immersive experience that enables customers to truly explore and experience the transformative potential of smart and decorative lighting. This milestone further strengthens our commitment to enriching homes with cutting-edge products that reflect our vision of Brighter Lives Better World."

This store is designed to meet the customers' home lighting requirements, ranging from decorative lights like chandeliers, wall lights, floor lamps and track lights to functional lights like modular COB, downlighters, magnetic tracks, panels, and spots. The store also features WiZ, its smart lighting solutions and smart services that offer customers connected lighting, so they can enjoy their daily moments with more comfort and ease. EI

Overcapacity in Solar Module Manufacturing Industry to Moderate Profitability

ICRA expects the solar photovoltaic (PV) module manufacturing capacity in India to increase to over 165 GW by March 2027 from ~109 GW at present, led by strong policy support in the form of the Approved List of Models and Manufacturers (ALMM), which effectively barred the direct import of modules, along with the imposition of basic customs duty on imported cells & modules, and the Production-Linked Incentive (PLI) scheme. The implementation of ALMM List-II for solar PV cells from June 2026 has spurred the ongoing expansion of cell manufacturing capacity by module Original Equipment Manufacturers (OEMs) in India, which is likely to increase to about 100 GW by December 2027 from 17.9 GW currently under ALMM.

The industry is poised to face a potential overcapacity scenario as the annual solar capacity installation is expected at 45-50 Giga Watt direct current (GWdc) against an annual solar module production of 60-65 GW. Further, the recent imposition of US tariffs has adversely impacted the export volumes, posing new challenges for the industry as the modules have been redirected from the export market to the domestic market. Hence, the overcapacity in module production is likely to result in a consolidation of the smaller/pureplay module players. However, ICRA anticipates the vertically integrated manufacturers to benefit over the long term due to greater control over the supply chain. EI

Servotech Renewable Secures New Solar Projects


Sarika Bhatia

Servotech Renewable Power System Ltd. has been awarded a ₹16.31 crore ground mounted and rooftop on-grid solar project by Railway Energy Management Company Limited (REMCL), a Joint Venture of RITES Ltd. and Ministry of Railways.

Commenting on the project, Sarika Bhatia, Whole-Time Director, Servotech, said, "We are proud to work with REMCL on this solar project. Infrastructure like DFCCIL forms the backbone of India's logistics and freight movement, and integrating solar energy into such high-impact facilities is a major step toward national decarbonisation goals. This order highlights Servotech's engineering strength, execution capability, and consistent reliability in delivering solar solutions for large-scale infrastructure. We remain committed to supporting India's green transition through innovation, quality, and strong partnerships." EI

Vikram Solar Rolls out 'Hypersol Pro'


Gyanesh Chaudhary

Vikram Solar, one of India's leading solar PV module manufacturers, has unveiled its latest product, 'Hypersol Pro', at the Renewable Energy India (REI) Expo 2025. The new N-Type module has been meticulously engineered to deliver exceptional efficiency, reliability, and longevity for next-generation solar installations.

Commenting on the development, Gyanesh Chaudhary, Chairman & Managing Director, Vikram Solar, said, "With Hypersol Pro, we've engineered a module that embodies the next chapter of solar innovation, where design intelligence meets performance excellence. By integrating smart energy readiness and universal compatibility, Hypersol Pro reflects our vision of future-ready solar technology that empowers developers, industries, and communities alike. Innovations, like Hypersol Pro, are set to define the quality, dependability and global competitiveness of Indian solar manufacturing." EI

JOINTWELL® CABLE ACCESSORIES

JOINTWELL®
Cable Lugs & Connectors
Since 1975

(Merchant Exporters Cum Manufacturer & Exporter)
Shyam Industrial Estate,Unit-10,Ground Floor,
Off.Western Express Highway,
Behind Thakur Mall,Mira Road (East),
Thane – 401107,Maharastra,Bharat.
E–marketing@jointwellindia.net/response@jointwellindia.com
TEL:91-22-28488058,28488029 CELL: 9870018179/9820823436

TERMINALS & CABLE LUGS

COPPER ALLUMINIUM BI METAL LUGS & CONNECTOR

EARTH ROD, DIN RAILS, CABLE GLANDS

Celebrating 49 years of "Jointwell® Cable Accessories"

MANUFACTURERS AND EXPORTERS OF CABLE TERMINALS, CABLE SOCKETS,ALLUMINIUM COPPER BI-METAL LUGS, CABLE GLANDS, PVC SHROUDS,EARTH RODS, EARTH ROD CLAMPS, AND EARTHING ACCESSORIES,HOT FORGING PRODUCTS,DIN/MCB RAILS, HEAT SHRINKS.

GE Vernova Obtains First Onshore Wind Repower Upgrade Contract

GE Vernova's onshore wind turbine... Image Courtesy: GE Vernova

GE Vernova Inc. has secured its first onshore wind repower upgrade agreement outside the United States, signing with Taiwan Power Company (TPC) to supply 25 repower upgrade kits in Taiwan. The announcement was made during the B20 South Africa 2025 Summit in Johannesburg. The milestone international contract builds on GE Vernova's track record of repowering over 6,000 wind turbines in the United States, extending that expertise to support Taiwan's decarbonisation goals.

Under the agreement, GE Vernova will provide repower upgrade kits to repower 25 GE Vernova 1.5 MW-70.5m turbines and deliver a five-year Operations and Maintenance (O&M) services package. The order was booked in the third quarter of 2025. Initial components are scheduled for delivery in the fourth quarter of 2025, with retrofit installation taking place throughout 2026 and 2027.

Wind repowering enables turbines approaching the end of their designed operational life to be modernised and returned to service with improved reliability and performance. By extending asset life beyond original design life, the project will help TPC continue generating affordable, renewable electricity while maximising existing infrastructure.

Commenting on the development, Uzair Memon, Chief Commercial Officer for GE Vernova's Onshore Wind Services business, said, "As we bring our proven repowering capabilities to customers outside the U.S. for the first time, we're proud to work with TPC to support Taiwan's energy transition. The deal also reinforces how our services capabilities drive lifecycle value for our customers through fleet reliability, technology investment and an integrated global supply chain."

The step aligns with one of the recommendations of the Energy Mix & Just Transition policy paper released at the B20 Summit.

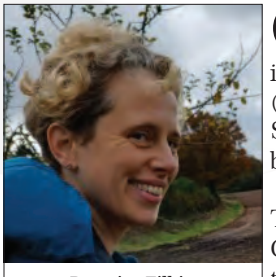
EDF Expands the Scope of Eligible Participants

Since the end of 2023, EDF has been offering long-term partnership contracts linked to the French historical nuclear fleet, known as 'nuclear production allocation contracts' (CAPN). These contracts allow partners to benefit from a share of the actual production of the historic nuclear fleet in exchange for sharing the associated costs and risks. Partners thus have access to low-carbon electricity supply for 10 or 15 years in France, at prices reflecting the costs of the nuclear fleet and therefore decoupled from wholesale markets prices.

Initially offered to energy-intensive companies, the scheme is now extended to a broader range of stakeholders including: i) Final consumers with annual needs exceeding 7 GWh; ii) Suppliers holding an authorisation to purchase electricity for resale to final consumers issued by the French administration (and/or any equivalent authorisation); and iii) Electricity producers.

Through this mechanism, EDF will make available a total volume of 1,800 MW of electricity, based on cost and risk sharing (approximately 10.6 TWh per year for an annual production level of 360 TWh from the historical fleet), for energy delivery in France starting January 1, 2027. A single contract model will be offered, based on a structure identical to contracts already concluded with an advance payment, sharing of production costs and associated risks. The system will ensure clarity and transparency for all actors located in one or more of the target countries.

Ofgem Releases Early Investment for Clean Energy



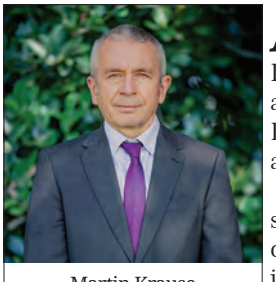
Beatrice Filkin

Ofgem has approved Early Construction Funding (ECF) requests for the following two projects: i) Eight Scottish Hydro Electric Transmission Plc (SHET) electricity transmission projects; and ii) Sealink, a proposed NGET transmission project between Suffolk and Kent.

The projects are part of the Accelerated Strategic Transmission Investment (ASTI) framework, Ofgem's streamlined process will help achieve the government's clean power goals including connecting 43 – 50GW of offshore wind by 2030.

Commenting on the development, Beatrice Filkin, Ofgem Director of Major Projects, said, "Releasing early investment to suitable projects equips British Transmission Operators to compete globally, avoid delays caused by supply chain constraints and secure the sought-after materials and components to boost our energy security and power our homes and economy."

New Investments Aim to Scale up Digitalisation



Martin Krause

At COP30, UNEP in collaboration with the International Energy Agency and supported by Italy's Ministry for the Environment and Energy, has announced the second phase of the Digital Demand-Driven Electricity Networks (3DEN) Initiative to advance 14 new projects across Africa and Brazil.

Phase II expands 3DEN's work beyond the power sector into the agri-food system, where innovative digital tools can dramatically reduce energy use, improve water efficiency and strengthen climate resilience.

Renewables are now the cheapest source of electricity globally, but many countries are unable to use them effectively due to grid inflexibility, outdated infrastructure, and a lack of digital tools. 3DEN supports countries to build smarter, more resilient and low-carbon energy and others.

EPOXY HOUSE®
Growth Through Innovation

1.1 kV → 3.6 kV → 220 kV

A Comprehensive Product Range from 1.1kV to 220kV.

Low Voltage

Medium Voltage

High Voltage

APPLICATIONS

- » Power Generation
- » Transmission & Distribution
- » Industrial Facilities
- » Smart Grid
- » Railways
- » Renewable Energy
- » Substations

BARODA BUSHINGS & INSULATORS PVT. LTD. | ECS INDUSTRIES PVT. LTD. | KAIZEN SWITCHGEAR PRODUCTS PVT. LTD. | BARODA MOULDS & DIES PVT. LTD. | FIBRETECH INDUSTRIES | GB SOLAR TECHNOLOGIES PVT LTD

: +91 8980035729 : sales@epoxyhouse.com : www.epoxyhouse.com

Corporate Office : Epoxy House, 248-249 A/B, G.I.D.C Estate, Makarpura, Vadodara, Gujarat - 390010, INDIA.

New Acquisition Positions ABB to Capitalise on IEA's Predicted Market Growth

This acquisition will strengthen ABB's position in renewable power conversion...

A global technology leader in electrification and automation ABB has completed acquisition of Gamesa Electric's power electronics business in Spain from Siemens Gamesa, originally announced on December 18, 2024. Financial terms were not disclosed. The business reported annual revenues of approximately €145 million for the fiscal year ended September 30, 2025.

The acquired portfolio includes power conversion products such as wind converters for Doubly-Fed Induction Generator (DFIG), industrial Battery Energy Storage Systems (BESSs), and utility-scale solar inverters. The transaction brings in around 400 employees, including key resources in India, China, United States, and Australia, and two converter factories in Madrid and Valencia.

ABB has also entered into a supply and services agreement with Siemens Gamesa. The acquisition increases the total capacity of ABB's serviceable installed base of wind converters by approximately 46 gigawatts and supports the profitable growth strategy of the Motion business area. With over 45 years of experience in power electronics, Gamesa Electric brings deep technical expertise in solar and renewable applications and strong customer relationships.

Commenting on the acquisition, Daniel Gerber, Business Line Manager, Renewable Power of ABB's Motion High Power Division, said, "By combining ABB's global reach and Gamesa Electric's portfolio and expertise, the company is well positioned to capture growing demand and accelerate renewable energy adoption worldwide."

According to the International Energy Agency, electricity generation from renewables is expected to increase 60% from 9,900 TWh in 2024 to 16,200 TWh in 2030. In fact, renewables are expected to surpass coal at the end of 2025 (or by mid-2026 at the latest, depending on hydropower availability) to become the largest source of electricity generation globally.

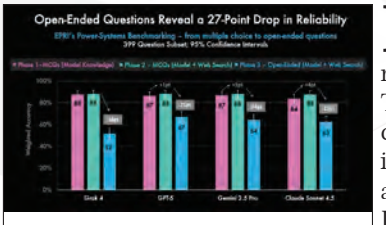
J-POWER Acquires State-of-the-Art Drilling Rig

J-Power Hytec Co., Ltd., a wholly owned subsidiary of Electric Power Development Co., Ltd. (J-POWER) has acquired a state-of-the-art large-diameter drilling rig for wells for geothermal power generation. The new rig will strengthen the J-POWER Group's efforts to ensure stable operation and advance the development of geothermal power generation facilities.

Geothermal power generation offers distinct advantages over other renewable energy sources, such as solar and wind power. It can operate around the clock, 365 days a year, unaffected by weather conditions, achieving high-capacity factors. With proper management of resources and equipment, geothermal plants can deliver long-term, stable power output for over 40 years. As decarbonisation efforts grow both globally and domestically, geothermal power is expected to help support the transition to carbon neutrality as a baseload power source.

Drilling geothermal wells (Well means boreholes drilled to survey, produce, and reinject geothermal resources. Wells are used to confirm resource volumes and to produce and reinject steam and hot water for power generation.) is crucial for exploration, construction, and stable plant operations after a geothermal power plant goes online. However, geothermal well drilling requires large-diameter drilling rigs, and only about ten companies in Japan possess such equipment.

EPRI Publishes First Electric Sector Benchmarking Results of Public LLMs

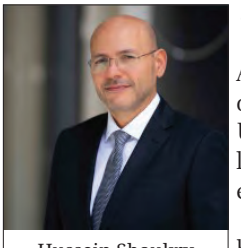


EPRI has utilised a dataset comprising more than 2,100 questions and answers, generated by 94 power sector experts...

EPRI has recently released first-of-its-kind, domain-specific benchmarking results for the electric power sector. This initial application includes multiple-choice and open-ended questions rooted in real-world utility topics, providing a more realistic view of how Large Language Models (LLM) perform. Results indicate expert oversight remains imperative, especially with open-ended questions, which could result in less than 50% accuracy in some cases.

Many existing benchmarks assess broad academic knowledge, such as math, science, and coding, and may not capture the operational and contextual complexity of real-world utility environments. Benchmarking with electric power-specific questions, such as generation and transmission and distribution asset-related inquiries, helps assess how well LLMs understand and respond to technical, regulatory and operational questions that utilities face.

Siemens Energy Appoints New MD for MEA Region



Hussein Shoukry

Siemens Energy has appointed Hussein Shoukry as the Managing Director (MD) for the Middle East and Africa, effective from December 1, 2025. Hussein holds a degree in Construction Engineering from the American University in Cairo. He brings extensive experience in leading complex energy projects and strengthening global execution capabilities to his new role.

Since joining the company in 2003, Hussein has held several leadership positions, most recently serving as the Senior Vice President for Project Execution, where he led a team of over 3,500 and oversaw Siemens Energy's global Competence Centers in Romania, Mexico, and India. As Managing Director, he will be based in the UAE.

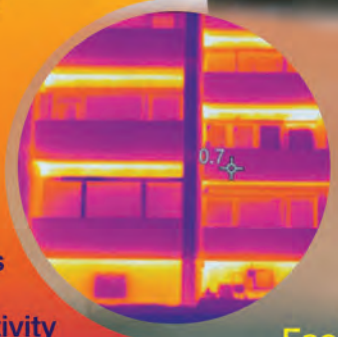
Be sure. testo

See Beyond the Surface

Testo Thermal Imagers for reliable & efficient thermal inspections

testo 872 | **testo 883**

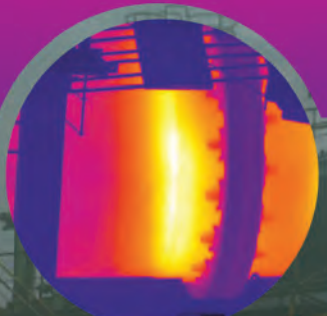
- Outstanding image quality can detect even the finest temperature differences.
- With testo IRSoft it is possible to creating detailed reports instantly.
- Automatic contrast adjustment for comparable thermal images.
- Ideal for early detection of imminent defects in the buildings, electrical components, plants and mechanical tools
- Precise measurement with Thermal sensitivity of 0.04 °C
- Wireless transmission of readings through testo 770-3 clamp meter and testo 605i thermohygrometer



Roof or wall heat intrusion

Mould risk tracing

Facade leakages



Hot furnaces

Electrical troubleshooting

Boiler

Application areas

Industrial maintenance

Building thermography

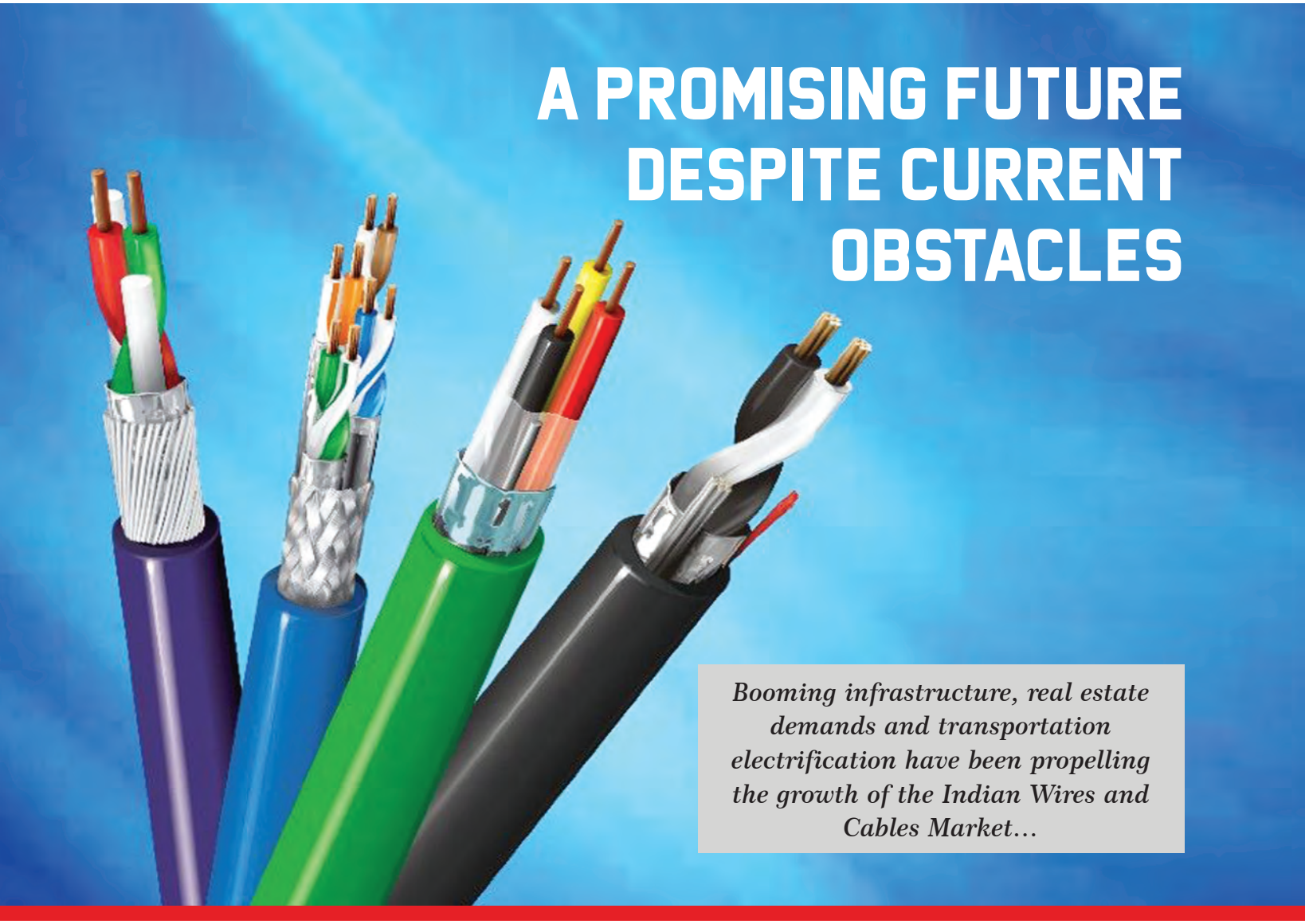
Testo India Pvt Ltd

+91 20 2592 0000 | info@testo.in

Designed in GERMANY

www.testo.com

A PROMISING FUTURE DESPITE CURRENT OBSTACLES



Booming infrastructure, real estate demands and transportation electrification have been propelling the growth of the Indian Wires and Cables Market…

The India Wires and Cables Market is expected to reach US$ 15.41 billion by 2033 from US$ 8.97 billion in 2024, with a CAGR of 6.20% from 2025 to 2033. A number of factors, including rising renewable energy output, expanding smart grid technology reserves, industrialisation, and government initiatives, are propelling the wire and cable market in India. This industry, which is essential for telecommunications and energy distribution, is growing at a remarkable rate and is predicted to keep up this trend in the years to come.

Growth Drivers for the India Wires and Cables Market

Infrastructure Development

India's aggressive ambitions for infrastructure development and fast urbanisation are two of the main factors propelling the wires and cables market's expansion. The need for dependable and effective electrical networks is rising dramatically as a result of projects under programs like Housing for All, Bharatmala Pariyojana (India's ambitious umbrella programme for highway development), and the Smart Cities Mission.

For power distribution, lighting, communication and automation, these massive improvements in transportation (highways, metros), urban housing, commercial complexes, and utility services necessitate significant wiring and cabling systems.

Adoption of premium, fire-retardant, and environmentally friendly cable solutions is also being pushed by the growing emphasis on safety and energy efficiency. The demand for sophisticated wires and

PERFECT PROTECTIVE PACKAGING

PERFECT PACKAGING MEANS OFFERING RELIABLE PROTECTION FOR EACH APPLICATION.

PAPERplus®

AIRplus®

FOAMplus®

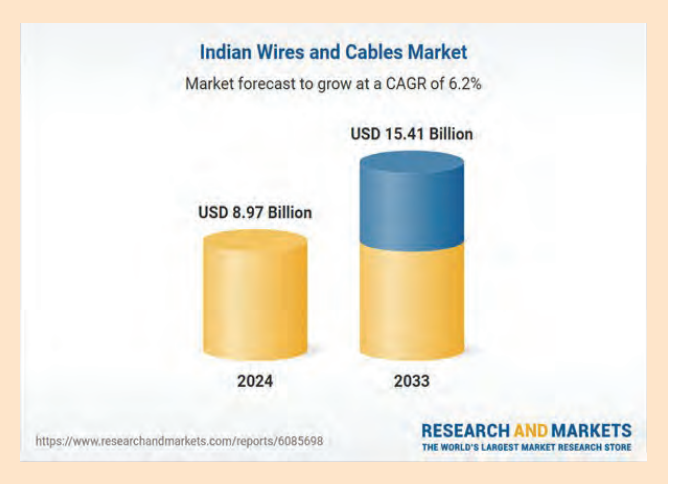
Each product has its very own requirements in terms of protective packaging.
With our paper, air, and foam packaging systems we have just the right solution for any application.
Whether filling voids, cushioning from impact shock or blocking and bracing goods against transport damage: Storopack's PAPERplus® paper cushioning offers all-around perfect protection for your packaged goods. PAPERplus® is now being manufactured in India making it a great blend between German technology and Indian operations.
FOAMplus® offers the protection required for your heavy or fragile products and anything with awkward shapes. Made from expanded polyurethane, the high-quality packaging foam is resistant, robust and light weight.

Storopack India Private Limited

412308 Pune, India

T +91 76779 76779
packaging.india@storopack.com

More about Storopack's - product range: www.storopack.in/products/flexible-protective-packaging



cables keeps growing as infrastructure spreads throughout urban and semi-urban areas, fostering the industry's steady expansion.

Real Estate and Housing Demand

The market for wires and cables is expanding due in large part to India's growing need for residential and commercial structures. The real estate industry is growing in metro areas as well as tier 2 and tier 3 cities due to factors like rising incomes, fast urbanisation and government initiatives like the Pradhan Mantri Awas Yojana (PMAY).

The need for dependable electrical infrastructure, such as communication cables, low-voltage power cables and building wires, has increased by this expansion. Advanced wire systems for automation, safety, power distribution and lighting are becoming more and more necessary in modern structures. High-rise apartment buildings and commercial complexes are placing a greater emphasis on fire safety and energy efficiency, which is encouraging the use of premium, flame-retardant cables and propelling the market's growth.

Electrification of Transportation

One of the main factors propelling the wires and cables market in India is the continuous electrification of the country's transportation infrastructure. The need for specialised, high-performance cables is rising as a result of significant investments in metro rail projects throughout cities and the quick development of EV infrastructure.

These consist of traction system power cables, EV charging infrastructure, and signalling and control systems. The rollout of EVs and charging stations is also being accelerated by government programs such as the National Electric Mobility Mission and Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME). These advancements necessitate cables that are safe and able to tolerate high voltages and temperature changes. The need for cutting-edge cable solutions in this industry is expected to increase significantly as the drive for sustainable, clean transportation heats up.

Challenges in the India Wires and Cables Market

Counterfeit Products

One of the biggest problems facing the Indian wires and cables sector is the pervasiveness of fake and inferior cables. These counterfeit goods are frequently offered at reduced costs, which appeals to budget-conscious buyers and smaller contractors who could put price above quality.

However, fake cables frequently fall short of performance and safety requirements, raising the possibility of electrical fires, system malfunctions and safety risks.

In addition to putting people and property in danger, this harms respectable manufacturers' reputations. Furthermore, the existence of these goods leads to unfair competition, which hurts quality-focused firms' sales and profitability. Stricter quality controls, increased public awareness, and stronger regulatory enforcement are required to stop the spread of these dangerous and illegal goods.

Compliance and Standardization Issues

The uneven application of safety and quality regulations is one of the major issues facing the Indian wires and cables industry. Many items still reach the market without the necessary conformity, even with the existence of regulatory agencies and well-established standards like ISI and BIS certificates. As a result, inferior cables are widely distributed, particularly in unorganised and rural marketplaces.

In addition to endangering electrical safety, non-compliant items damage consumer confidence and damage the industry's brand as a whole. Low-quality substitutes unfairly compete with reputable producers who uphold quality standards. To guarantee safety, encourage uniformity, and preserve market integrity, it is imperative to bolster regulatory monitoring, expand industry audits, and increase end-user knowledge of certified items.

For further information: https://bit.ly/48pTcFv

Empowering a more reliable future with Nomex®

Nomex® 410 and Nomex® 926 work together to redefine transformer design—enabling smaller, more compact units that reduce installation footprint while delivering exceptional performance.

These high-performance insulation papers combine superior thermal stability and dielectric strength, allowing for optimized designs that save space and materials. Both grades help ensure unmatched reliability and uptime, with low maintenance requirements throughout the life cycle.

They are compatible with most insulating liquids, including natural and synthetic esters, giving you flexibility for sustainability and application needs.

Together they offer: Smaller transformers. Bigger uptime.

DUPONT
Nomex®

EI.Nomex.com

RWE Modernises a Wind Farm

Repowering of Calle wind farm has begun: three turbines with total capacity of 17.1 MW to replace five older units with 9 MW in total; electricity generation to increase fivefold…

RWE has started to modernise its Calle wind farm in Lower Saxony. Three state-of-the-art 5.7-megawatt (MW) turbines, with a total capacity of 17.1 MW, are replacing five turbines built in 2004 that have a combined output of 9 MW. The dismantling of the old installations has already begun. RWE was awarded the repowering contract in the latest onshore wind auction held by the Federal Network Agency. The three new turbines, located in the district of Nienburg in the municipality of Bücken, are scheduled for full commissioning at the end of 2026.

The existing Calle wind farm…
Image Credit: RWE

Detailing on the project, Katja Wünschel, CEO RWE Renewables Europe & Australia said, "Calle clearly demonstrates the potential of modernising older wind farms. The five old turbines are being replaced by three state-of-the-art ones. This will almost double the total capacity and increase electricity generation fivefold. The new turbines will be able to supply the equivalent of around 16,000 households with climate-friendly electricity. The region will also benefit, as we will pay a total of 0.3 cents per kilowatt-hour generated to the surrounding municipalities, including the 0.1 cents stipulated by the Lower Saxony Participation Act. This could generate annual revenues of up to 150,000 euros."

Sustainable approach through recycling and promoting biodiversity

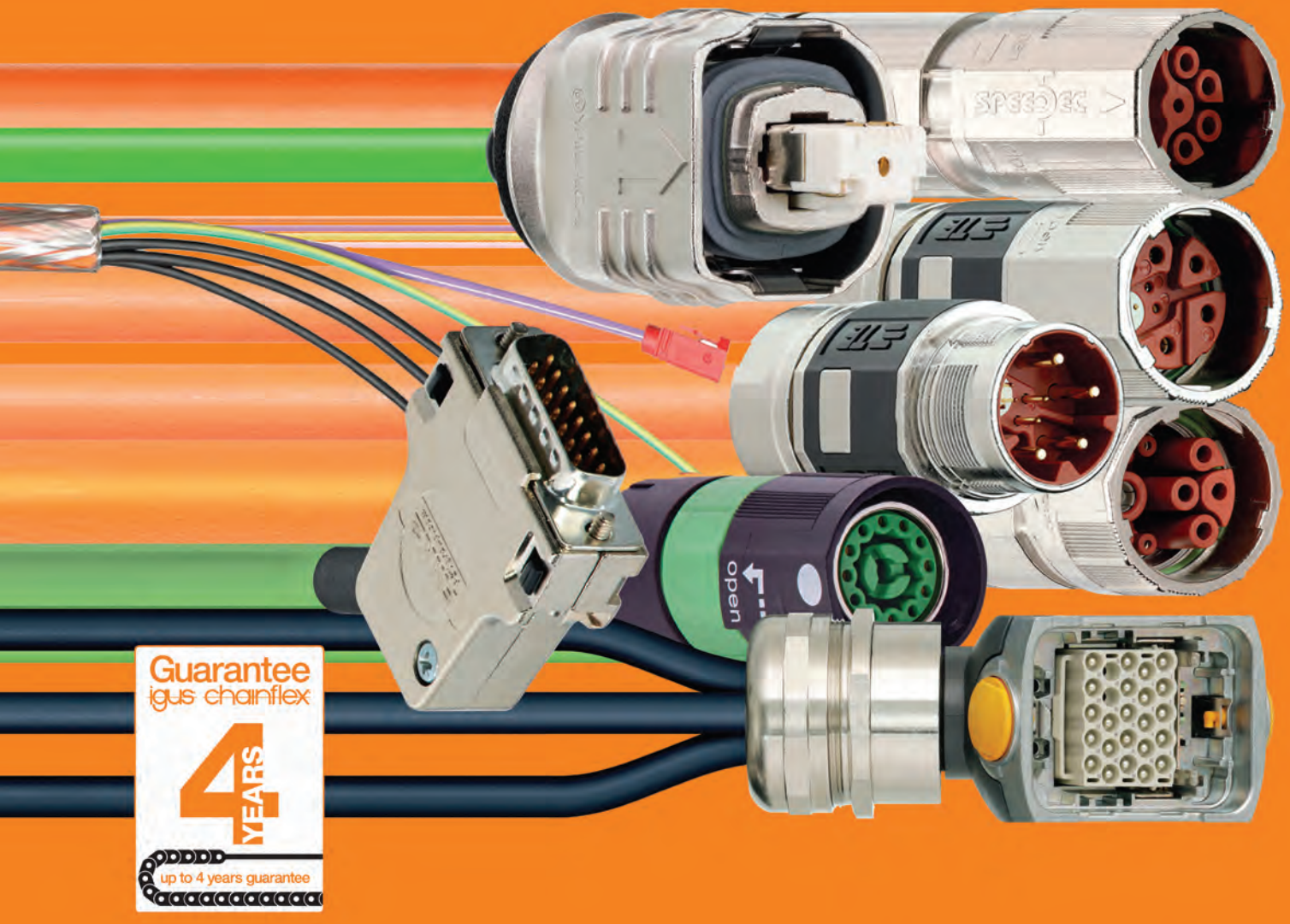
In its dismantling and newbuild activities alike, RWE is committed to sustainability throughout the entire process. For example, at the Calle wind farm, the concrete from the old foundations is being reused to build access roads to the new wind farm. One of the former towers is being re-erected at another wind farm, while the remaining components are being properly recycled. Although not necessary for the new development, RWE is voluntarily continuing its compensatory measures from the existing park, such as orchards, hedgerows, and natural woodland areas. Additionally, RWE is planning further initiatives to promote biodiversity in close cooperation with the landowners, such as the creation of flowering strips.

Green growth in the domestic market

The use of onshore wind energy plays a crucial role in the energy transition and is one of the main pillars in the expansion of renewable energies. RWE is currently constructing wind farms in its domestic market, with a planned total capacity of 167 MW, and already has 737 MW in operation. To ensure a strong presence in the locally driven wind and solar business, RWE is represented across Germany by nine regional offices, in addition to its headquarters in Essen.

readycable®

... over 5,000 drive cables



Guarantee
igus chainflex
4 YEARS
up to 4 years guarantee

... customized solutions
... suitable for 30 manufacturer standards
... to your required length: with centimetre accuracy
... no minimum order value, from quantity 1

igus®.in
/readycable

igus®(India) Private Limited,
#1, Survey No. 34 Mandur, Devanahalli Road,
Mandur Village Bidarahalli Hobli, Bangalore - 560049, Karnataka, India
Phone : +91 80 69116900 Fax : +91 80 68127802

An Overview of the INDIAN POWER SECTOR

Indian power sector is growing rapidly to make our country self-reliant in a sustainable way. However, still we need to urgently overcome some major challenges…

- P. K. Chatterjee (PK)

I don't think there can be any disagreement that India's power sector is progressing at a rapid pace under the supervision of our current government. Placing two ministers in charge of the power sector (Power + New & Renewable Energy) at the outset of forming the new government was undoubtedly a far-sighted decision. The benefits of which are now being witnessed.

India has the third-largest power sector globally in terms of electricity production and consumption, and it is a world leader in the growth of power generation capacity, particularly in renewable energy. Our country has achieved near-universal household electrification – and has set ambitious targets for non-fossil fuel capacity by 2030. In this article, I am trying to shed light on several significant changes that have occurred in India's power sector in 2025, and some challenges that we still need to overcome.

Our power sector at a glance today

India has made significant progress in strengthening its energy (power) sector in recent years. Our country is successfully balancing the twin goals of meeting rising electricity demand and promoting sustainability.

According to the International Energy Agency (IEA), "85% of the increase in global electricity demand over the next three years will come from emerging and developing economies. As one of the fastest-growing major economies, India plays a central role in the global energy transition. Its energy demand is expected to grow at the fastest rate among major economies, driven by sustained economic growth. Consequently, India's share in global primary energy consumption is projected to double by 2035."

Over the past decade, India's power sector has seen robust expansion driven by rising demand, infrastructure development, and strong policy support for both conventional and renewable energy sources.

A few notable facts

- **Production and consumption:** India is the world's third-largest producer and consumer of electricity, following China and the United States.

- **Growth:** It ranks third globally in power generation growth over the past five years and is a leader in adding new capacity, driven significantly by renewables.
- **Renewable energy:** Our country is a major force in renewable energy, ranking fourth in renewable energy installed capacity, third in solar power, and third in wind and solar power generation combined. As of October 2025, over 51% of India's total installed capacity comes from non-fossil fuel sources.
- **Electrification:** Our country has achieved near-universal household electrification, though the quality and reliability of supply can vary by region.
- **Targets:** Our nation is committed to a goal of 500 GW of non-fossil fuel capacity by 2030.

Significant progress in 2025

In 2025, our power sector has made significant strides, particularly in renewable energy, achieving its highest-ever renewable energy share in generation and surpassing 50% of installed capacity from non-fossil fuel sources ahead of schedule.

Key progress includes crossing 100 GW in solar capacity and 50 GW in wind capacity, the launch of reforms like the Electricity (Amendment) Bill, 2025, and an increase in solar module manufacturing capacity.

Renewable energy expansion

- **Record renewable energy share:** In July 2025, renewable sources supplied over 50% of the country's total electricity demand for the first time.
- **Installed capacity milestones:** Our country has crossed 100 GW in solar capacity and 50 GW in wind power capacity.
- **Solar power growth:** India has become the world's third-biggest solar energy producer, surpassing Japan.
- **Increased manufacturing:** Solar module manufacturing capacity has grown significantly, rising from 38 GW to 74 GW during the 2024–25 fiscal year.

Policy and reform

- **Electricity (Amendment) Bill, 2025:** New provisions have been introduced to reform the power sector, including regulating wheeling charges and defining the role of energy storage systems.
- **Increased investment:** The sector has seen a substantial investment of ₹84,309 crore in the first quarter of 2025.

Grid and infrastructure

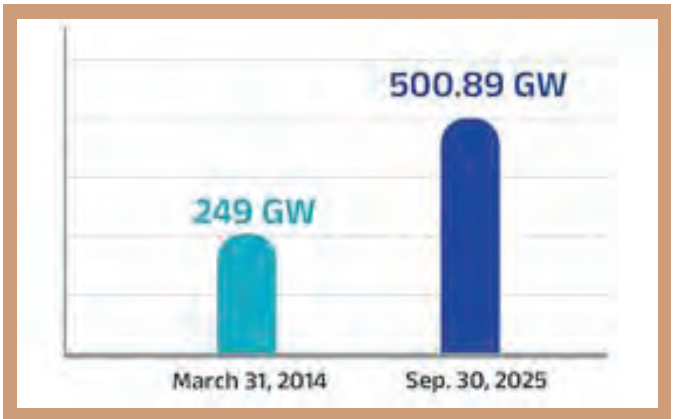
- **Grid modernisation:** Efforts are now underway to modernise the grid through smart grid pilots and the deployment of technologies like bifacial solar panels and AI-driven forecasting platforms.
- **Improved reliability:** Electricity shortages fell sharply to 0.1% in FY25 from 4.2% in FY14, indicating improved supply reliability.
- **EV charging integration:** The integration of solar power with Electric Vehicles (EVs) is expected to grow significantly, leading to more solar-powered EV charging stations.

Strong growth in total capacity

As per International Energy Agency (IEA), "Electricity demand in India has been rising sharply due to increases in commercial and residential space, a surge in ownership of air conditioners and appliances, and rising demand from industry. India has seen the third-largest growth in power generation capacity in the world after China and the United States over the past five years. While growth in power generation has come from all sources, there has been a surge in investment in renewables, led by solar PV, which constitutes more than half of total non-fossil investment over this period. In 2024, 83% of power sector investment went to clean energy. India was also the world's largest recipient of development finance (DFI) funding in 2024, receiving around USD 2.4 billion in project-type interventions in clean energy generation. This helped bring the share of non-fossil power generation capacity to 44% in 2024, approaching India's target of 50% by 2030." However, India has achieved more than 50% of its installed power capacity from non-fossil fuels in June 2025, ahead of its 2030 target.

Foreign direct investment status

According to IEA, "India has announced a range of measures to facilitate and support investment in non-fossil power generation, domestic manufacturing of key energy components such as batteries and solar PV modules, and in transmission and distribution. While a large share of the investment in India's power generation capacity and transmission networks is met by domestic sources, Foreign Direct Investment (FDI) has been growing steadily, reaching USD 5 billion in 2023, nearly double the pre-coronavirus (Covid-19) levels. This is promoted in part by rules permitting 100% FDI across electricity generation sources (with the exception of nuclear) and transmission infrastructure. However, foreign portfolio investment in energy has declined in the past two years due to a range of macroeconomic and sectoral factors, even as the longer-term trend has been one of steady growth."



Our country's total installed electricity capacity has reached 500.89 GW...

Is the domestic investment enough?

Although the Indian power sector is progressing quite satisfactorily, it is yet to receive enough finance from domestic investors to meet its massive investment needs. However, significant capital is being mobilised at present.

Domestic financial institutions and government-owned NBFCs like PFC, REC and IREDA are major sources of debt, still, there is a substantial gap between projected demand and current supply. The sector requires more infusion of private capital.

A few key achievements and progress in 2025

India's power sector has achieved two historic milestones that show our nation's steady progress toward a clean, secure and self-reliant energy future.

As of September 30, 2025, our country's total installed electricity capacity has crossed 500 GW, reaching 500.89 GW. This achievement reflects years of strong policy support, investments and teamwork across the energy (power) sector.

A summary of the major developments

- **Milestone achievements:** As of September 2025, India's total installed electricity capacity has surpassed 500 GW. Critically, non-fossil fuel sources (renewables, hydro and nuclear) now account for over 51% of this capacity, a goal achieved five years ahead of the 2030 target set at the COP26 climate conference.
- **Renewable energy surge:** India ranks globally as the 4th largest in renewable energy installed capacity, 4th in wind power, and 3rd in solar power capacity. The installed renewable energy capacity has nearly tripled in the last decade.
- **Reduced power shortages:** Energy shortages have significantly dropped from 4.2% in 2013-14 to a minimal 0.1% in 2024-25, indicating improved supply reliability.
- **Universal access:** Our country has achieved 100% village electrification by April 2018 and has since connected over 28 million households to the grid through schemes like the Saubhagya program.
- **Increased consumption and infrastructure:** Per capita electricity consumption has increased by over 45% in the last decade, and the national power grid has been unified and strengthened.
- **Policy support:** Government initiatives like the PM Surya Ghar: Muft Bijli Yojana are promoting rooftop solar and empowering consumers as energy producers, supported by substantial financial outlays.

Before I leave

As our power sector will require an estimated ₹4.5-6.4 lakh crore investment until FY35 – more investment, especially from domestic investors, is required.

As per IEA, "India's cost of capital for grid-scale renewable energy is one of the lowest among its emerging market and developing economy counterparts. However, it is still 80% higher than in advanced economies." This aspect should be addressed immediately.

The rapid expansion of variable renewable energy (solar and wind) is outpacing the grid's ability to manage intermittent supply, creating instability and potential power shortages, especially during peak evening hours. The development of large-scale energy storage systems (pumped hydro and batteries) and smart grid technologies is crucial but still nascent.

Still there is a significant lag in the development of Transmission and Distribution (T&D) infrastructure relative to generation capacity. Issues like land acquisition delays, slow project approvals, and right-of-way issues hamper the evacuation of power from resource-rich areas to demand centres. These issues need to be looked upon.

Inconsistent policies across different states, delays in determining cost-reflective tariffs, and a complex regulatory framework are creating an unpredictable environment for private investors. The ongoing push for the Electricity (Amendment) Bill, 2025, aims to address some of these issues by promoting competition and financial discipline. However, it is still facing opposition from various groups who fear it will lead to privatisation and higher tariffs. This issue must be cleared ASAP.

We are stepping into 2026, thus to fulfil our commitments for 2030; which are: to achieve 500 GW of non-fossil fuel-based electricity capacity and reduce the emissions intensity of its GDP by 45% from 2005 levels; addressing the above issues is very urgent.

powerol
BY mahindra

mTORQUE

BSV Series Engine
Range 24.8hp to 265hp

- Low Fuel Consumption*
- Low Maintenance Cost*
- Best-in-class Cold Start ability*
- Best-in-class Torque*

WIDE APPLICATIONS


Mini Compactors


Forklifts


Cranes


SLCMs

*Conditions Apply

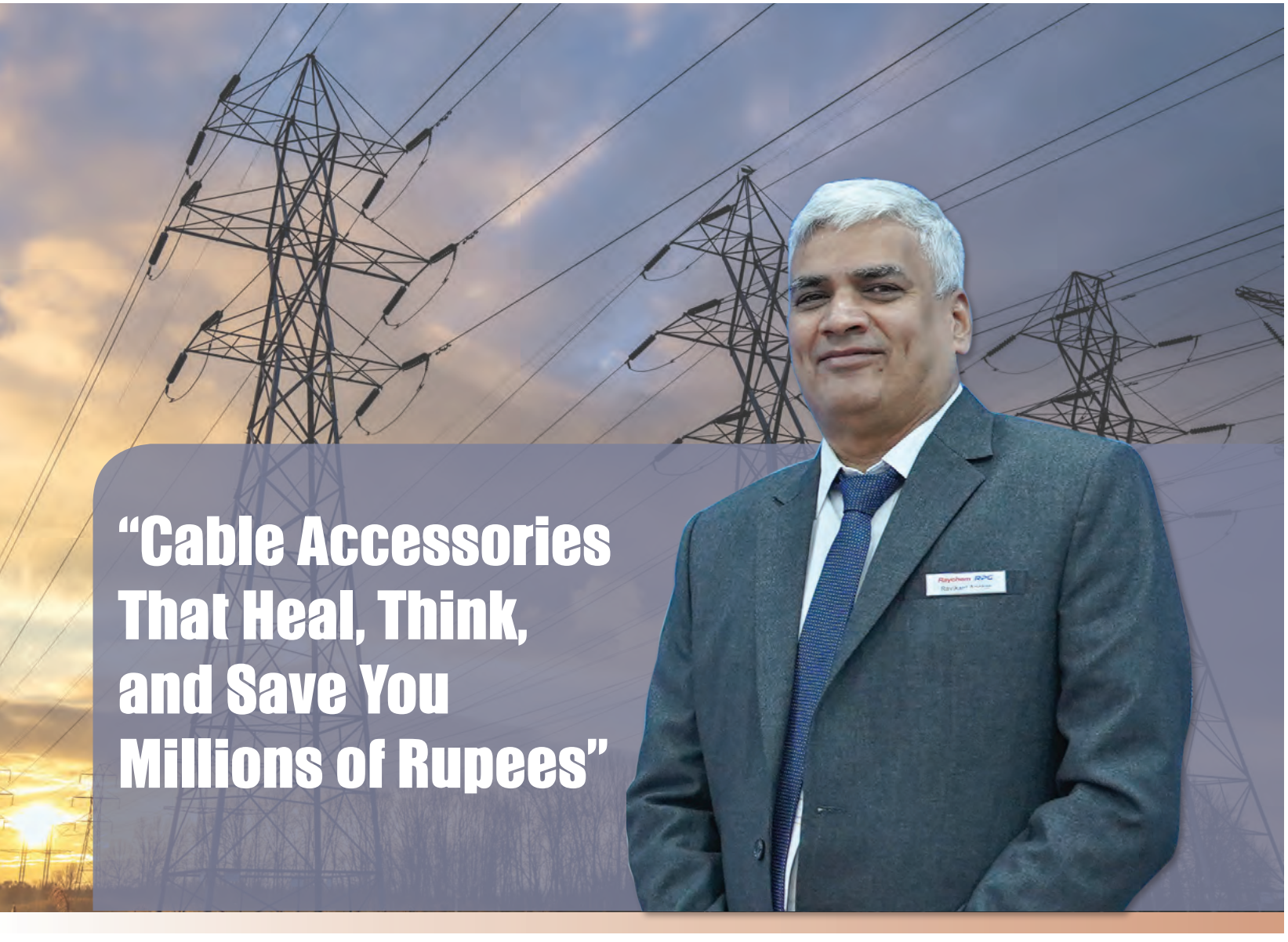
Please visit our stall at EXCON 2025

Bangalore International Exhibition Center (BIEC)

9 - 13 December 2025 | STALL NO. OD 45

www.mahindrapowerol.com

Call: 1800 419 1999



"Cable Accessories That Heal, Think, and Save You Millions of Rupees"

__Raychem RPG__ is pioneering in delivering innovative, reliable, and sustainable __Cable Accessories__ solutions for India's power sector. Their accessories power Indias ambitious 500 GW solar surge and also support and empower a wide range of leading industries including Defence and Aerospace, Infrastructure, Energy, Transportation and many others. In an e-interview with the Editorial Team of Electrical India, __Ravikant Anekar, DGM - Product Lead - Cable Accessories,__ speaks about the pioneering technologies and their impact on India's power infrastructure…

How is the Cable Accessories business of Raychem RPG growing globally & in India?

Raychem RPG's Cable Accessories business continues to achieve robust growth in India. The surge in global electrification, combined with TE's technological innovation and our focus on localisation, is driving significant worldwide expansion. In India, the business is witnessing robust momentum with consistent double-digit growth, supported by the **"Make in India"** & **"Atmanirbhar Bharat"**

initiative. Today, Raychem RPG stands as a market leader in High Voltage Cable Accessories up to 245 kV, holding over 60% market share and strengthening its position as a trusted partner in the nation's power infrastructure growth.

What kind of technological excellence or uniqueness can be found in the products offered by Raychem RPG?

Raychem RPG is the only Indian manufacturer with fully tested and certified High Voltage Cable Accessories. Our uniqueness lies in advanced material science built through years of global research and innovation. Every product is designed based on direct voice of customer, ensuring solutions that address real needs and pain areas.

How do you see the current trends in insulation, termination, and jointing technologies shaping future product development?

The future of insulation, termination, and jointing technologies is being shaped by digitisation and predictive asset management. We see XLPE insulation evolving toward smarter, more sustainable polymers especially for offshore installations, desert solar projects, and seismic zones. Switchgear systems are moving toward compact, modular cable connections with higher thermal conductivity and greater ampacity. Overall, the demand is rising for solutions that offer enhanced resilience in extreme environments.

What are your latest offerings for the industries?

Raychem RPG's latest offering includes the indigenously developed 145 kV Self-Supporting Outdoor Dry-Type Termination, designed to make installation significantly simpler, faster, and more reliable. We are proud to be the pioneers of this technology first time in India.

What are some of the biggest challenges the cable accessories market faces today?

One of the most pressing challenges in the cable accessories market today is the widening skill gap specifically at the ground level jointers. At the same time, the industry is navigating a perfect storm of supply chain disruptions, rigorous regulatory changes, and rapid technological advancements. Together, these factors are compelling manufacturers to reinvent product designs, streamline their supply chains, and adapt their business models to stay competitive.

What kind of modern technologies are in demand in India now-a-days as far as power segment is concerned?

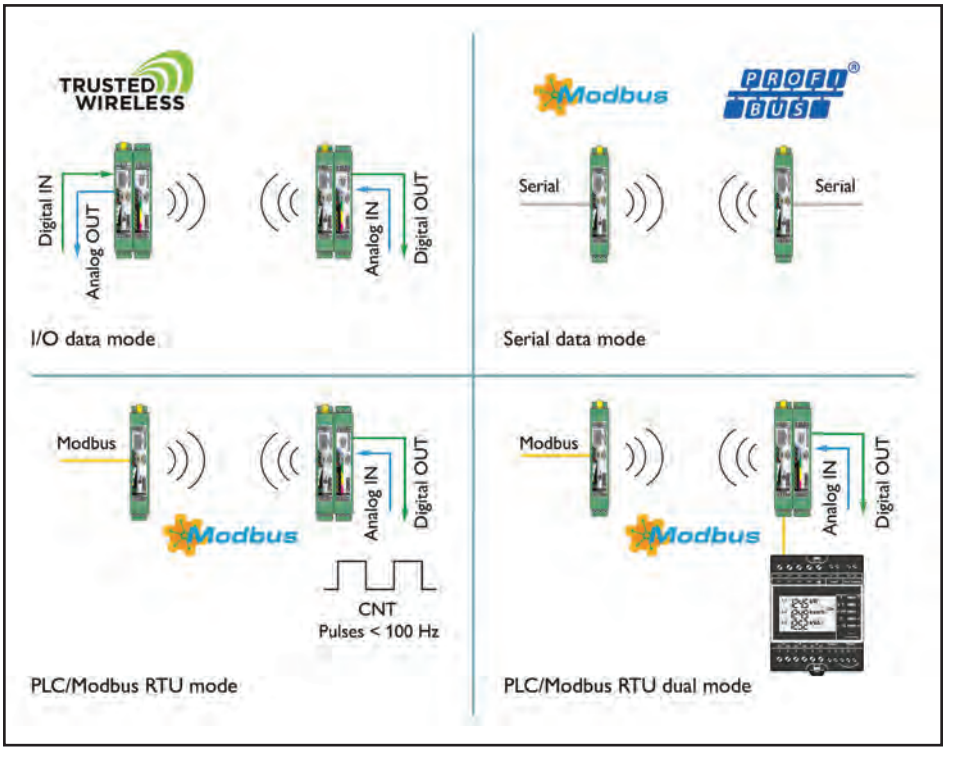
India's power sector is embracing cutting-edge technologies to strengthen grid resilience, integrate renewables, and enhance efficiency, leveraging Ai, BESS, hybrid PV, green hydrogen, small modular reactors, dynamic line ratings, and advanced grid enhancers.

What would you like to communicate to your potential buyers?

Raychem RPG goes beyond products. We deliver innovation, provide customized solutions, and stand as a trusted partner with the purpose to deliver Reliable Connections. Always…

Industrial wireless: Trusted wireless 2.0 Radio line for material handling by Phoenix Contact

Use of wireless technologies in automation technology is increasing year by year. Users benefit from this, as wireless solutions offer a higher degree of mobility and flexibility. Often it is the cost saving from the elimination of cable installation for the use of a wireless system. The automation industry focuses mainly on wireless technologies, which can be used practically worldwide and function in license-free frequency bands. Thanks to the large bandwidth of 83MHz, a high data throughput and/or the parallel operation of multiple wireless systems in the 2.4 GHz ISM band is possible.



As information is transmitted through the unprotected air, security strategies have to prevent the unauthorized access. With the widely distributed wireless technologies Bluetooth and Wireless LAN, the problem is that the communication interface is accessible for everyone, i.e. every available Bluetooth or WLAN wireless product fundamentally permits a connection with the industrially employed network. The potential danger is especially high with the WLAN interface, since it extremely common in the PC environment and very vulnerable to hacker attacks. Thanks to the closed technology of an industrial wireless path with Trusted Wireless 2.0. In principle, it is much better protected against possible attacks. Moreover, the frequency hopping method makes spying on the protocol much harder. But, Trusted Wireless 2.0 also has two genuine security mechanisms, an encryption of all transmitted information in accordance with the Advanced Encryption Standard (AES), as well as a user data integrity check described in accordance with RFC3610.

Areas of application for Trusted Wireless 2.0

Trusted Wireless 2.0 is a wireless technology developed specially for industrial use. It is particularly suitable for sensor-actuator information covering cable infrastructure. It is used in small to medium-sized data quantities, over larger distances of hundreds of meters to several kilometres. Trusted Wireless 2.0 is characterized by its particularly good adaptability to the desired industrial application and offers a high degree of reliability, robustness, safety and flexibility.

The main features of Trusted Wireless 2.0 are:

- Robust communication thanks to FHSS (Frequency Hopping Spread Spectrum)
- Automatic and manual coexistence mechanisms
- Secure communication due to encryption (AES 128 Bit) and integrity check
- Long range thanks to high receiver sensitivity and variable data transmission rates
- Flexible networks with automatic connection management
- Distributed network maintenance makes things easier and faster
- Extensive diagnostic properties
- Adaptability to the desired application.

More information: E-mail- adverts@phoenixcontact.co.in, Website: www.phoenixcontact.co.in

KUSAM-MECO®
An ISO 9001:2015 Company
SINCE 40 YEARS

NO. 1
FOR HIGH SAFETY
TEST & MEASURING INSTRUMENTS

THINK SAFETY
THINK KUSAM-MECO®

MULTIFUNCTION INSTALLATION TESTER
MODEL - KM 5100

NEW

KM 5100 rugged Multifunction Installation Tester with 3.5" TFT color LCD display, provides insulation resistance, earth resistance, loop impedance, voltage, RCD, PFG and PSC testing. It is designed with software system and ensure the safety of electrical installations in domestic, commercial and industrial applications.

FEATURE :

- 3.5" TFT color LCD display with 320 x 240 pixels
- Insulation Range upto 1000V / 4000 Mega Ohms
- Low Resistance Range upto 400 Ohms
- Earth Resistance Range upto 2000 Ohms
- Short Circuit Current ≥ 200mA
- Loop Resistance & RCD Testing Function
- Voltage & Frequency Measurement
- Continuity Beeper
- Variable RCD current mode for customized settings
- Support SD memory and USB and Bluetooth interface
- Slim probes designed with test button

TEST ADAPTER KIT FOR ELECTRIC VEHICLE CHARGING STATIONS
MODEL KM-EVA

NEW

FEATURE :

- **Input Voltage :** Max 250V (single phase); Max 430V (three phase) 50 / 60Hz
- Supply safe connection between charging station and instruments/meters
- With ø4MM terminals (3P + N + E) easy to conduct various tests
- Suitable For all kinds of EV instruments / meters
- IEC62196-2,Type 2 connector
- CAT II 300V Double insulated
- CE & UKCA confirmity assessed
- Working Temperature : 0 ~ 40°C
- Safety : EN61010 EMC EN61326

KUSAM-MECO®
An ISO 9001:2015 Company

Shop No.18, 1st Floor, CIDCO Shopping Complex, Plot # 9, Sector-7, Rajiv Gandhi Marg,
Sanpada, Navi Mumbai - 400705. Tel : +91-9867488006 / 9867675093
E-mail : sales@kusam-meco.co.in Website : www.kusamelectrical.com

What is Power Generation?

India is accelerating its power generation transformation through a comprehensive strategy focused on massive renewable energy deployment, supportive policies and the development of a resilient grid infrastructure...

Power generation is the critical process of converting various forms of primary energy (like chemical, kinetic or nuclear) into electrical power that can be transmitted and consumed by homes, businesses, and industries. It forms the essential foundation of modern society and is currently undergoing a massive global transformation towards sustainability.

The core principle behind nearly all utility-scale power generation is electromagnetic induction, discovered by Michael Faraday.

Here is a breakdown of the process, the main types, and the current global trends.

- **Prime Mover:** A source of energy (fuel, wind, water, etc.) is used to create a rotational or kinetic force.
- **Turbine:** This force spins the blades of a turbine (steam, gas, or hydro), converting the primary energy source into mechanical energy.
- **Generator (Alternator):** The turbine shaft is connected to a generator (alternator). The mechanical energy spins a rotor (electromagnet) inside a stationary coil of wire (stator), which induces an electric current—thus generating electricity.

The notable exception to this turbine-driven process is Solar Photovoltaics (PV), which converts sunlight directly into electricity using the photoelectric effect in silicon cells, with no moving parts.

Major Types of Power Generation

Power generation sources are broadly categorised into Fossil Fuels (conventional), Nuclear, and Renewable Energy Sources (RES).

Thermal Power (Fossil Fuels)

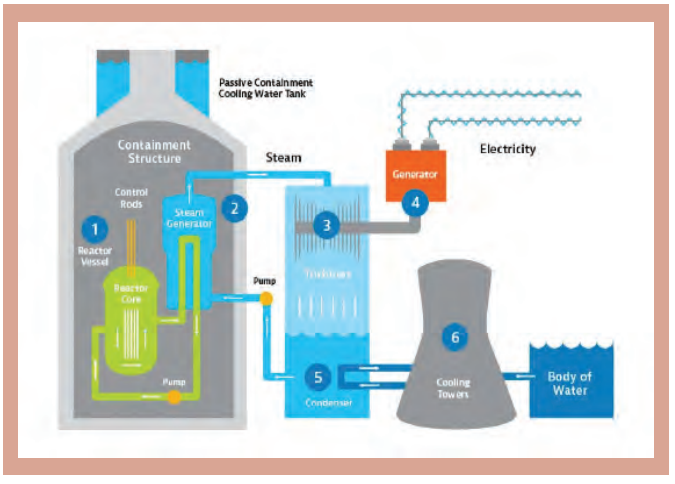
This is the traditional backbone of global power systems, providing base load power – reliable, continuous energy.

Source	How it Works	Advantages/Disadvantages
Coal	Burning pulverized coal heats water to create high-pressure steam, which drives a steam turbine.	**Advantage:** Abundant, established technology, reliable base load. **Disadvantage:** Highest greenhouse gas (GHG) and pollutant emissions.
Natural Gas	Burned directly in a **Gas Turbine** (like a jet engine) or in a highly efficient **Combined Cycle Gas Turbine (CCGT)** that also uses the exhaust heat to generate steam.	**Advantage:** Lower emissions than coal, faster start-up (peaking power), high efficiency. **Disadvantage:** Still a fossil fuel, subject to volatile gas prices.
Oil/ Diesel	Used primarily in smaller, localized generators or as an expensive backup source.	**Advantage:** Portable, reliable for emergencies. **Disadvantage:** High cost, high emissions.

Nuclear Power

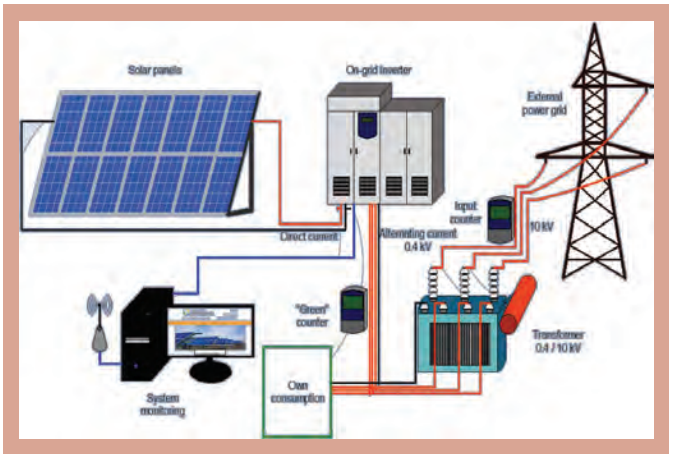
Nuclear power plants use nuclear fission (splitting of uranium atoms) to create heat, which boils water to produce steam, driving a turbine.

- **Advantage:** Zero-carbon power during operation, extremely high energy density (reliable base load), low fuel requirement.



- **Disadvantage:** High initial capital cost, long construction times, safe management of nuclear waste.

Renewable Energy Sources (RES)



These are naturally replenished sources that are the key to the global energy transition.

Source	How it Works	Characteristic
Solar Photovoltaic (PV)	Silicon cells convert sunlight directly into DC electricity, which is then converted to AC.	**Variable:** Generation occurs only when the sun shines. Fastest growing source globally.
Wind Power	Wind turns large blades, which drive a shaft connected to a generator.	**Variable:** Dependent on wind speed and weather. Extremely cost-competitive.
Hydropower	Falling water, often stored behind a dam, drives a water turbine.	**Dispatchable/Clean:** Can be turned on or off quickly (peaking power), but development is sensitive to environmental factors.
Geothermal	Uses heat from deep within the Earth to generate steam and drive turbines.	**Base Load Renewable:** Provides continuous, non-variable power, but is location specific.

Current Global Trends (2025)

The power generation landscape is evolving rapidly, driven by climate goals and technological breakthroughs:

- **Solar is Leading the Charge:** Solar PV is driving almost 80% of new global renewable capacity. For the first time, renewable energy sources (solar, wind, hydro) are now generating more electricity globally than coal.
- **The Rise of Gas in Developing Economies:** While developed nations phase down coal, many developing economies are increasingly relying on natural gas as a 'bridge fuel' to transition away from coal due to its lower emissions and flexible nature.
- **The Storage Imperative:** The intermittency of wind and solar makes Energy Storage Systems (BESS)

critical. Massive investment in batteries is necessary to 'firm up' renewable power and ensure grid stability.

- **Decarbonisation of Heavy Industry:** Focus is shifting to technologies like Green Hydrogen, which is produced using renewable electricity and can be used to decarbonise hard-to-abate sectors like shipping, steel, and chemicals.
- **Digitalization:** Smart grids, advanced sensors, and AI are being deployed to predict renewable energy output, manage two-way power flow (from rooftop solar), and enhance overall grid efficiency and stability.

A Transformation in India's Electricity Generation Landscape

India's power sector is undergoing one of the most dynamic and critical transformations in the world. As the nation sustains high economic growth and strives for universal energy access, it is simultaneously embarking on a monumental shift from fossil fuel dependence to an energy mix dominated by renewables. This dual mandate – meeting massive energy demand while pursuing decarbonization – defines the current state and future trajectory of power generation in India.

The Shifting Energy Mix: A Factual Overview

India's total installed electricity generation capacity has crossed a significant milestone, reaching approximately 501.9 GW (as of November 2025). The most remarkable feature of this capacity is the balance it now holds between conventional and non-fossil fuel sources, fulfilling a national commitment ahead of time.

Non-Fossil Fuel Dominance Achieved

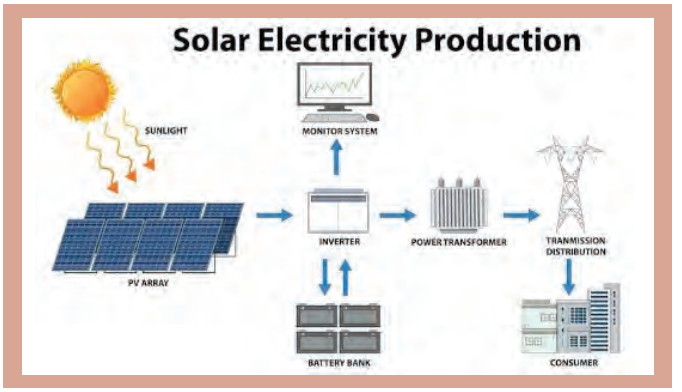
In a historic achievement, the capacity from non-fossil fuel sources (including Renewables, Large Hydro and Nuclear) has surpassed 50% of the total installed base (source - Ministry of Power in a PIB release in October 2025, utilizing the capacity data available up to September 30, 2025).

Category	Installed Capacity (GW)	Share of Total Capacity
Total Installed Capacity	~501.9 GW	100%
Non-Fossil Fuel Sources	~256.1 GW	~51.0%
Thermal (Coal, Gas, Diesel)	~245.8 GW	~49.0%
Renewables (Excl. Lg Hydro & Nuclear)	~197 GW	~39.0%

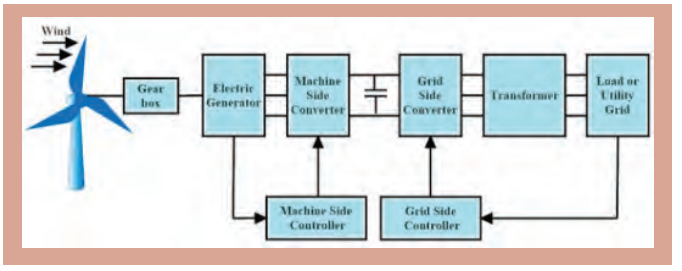
The Renewable Energy Surge

Renewable Energy Sources (RES) are the primary engine of this transition, driven by aggressive national targets to achieve 500 GW of non-fossil fuel capacity by 2030. India ranks among the top countries globally for installed wind and solar power capacity.

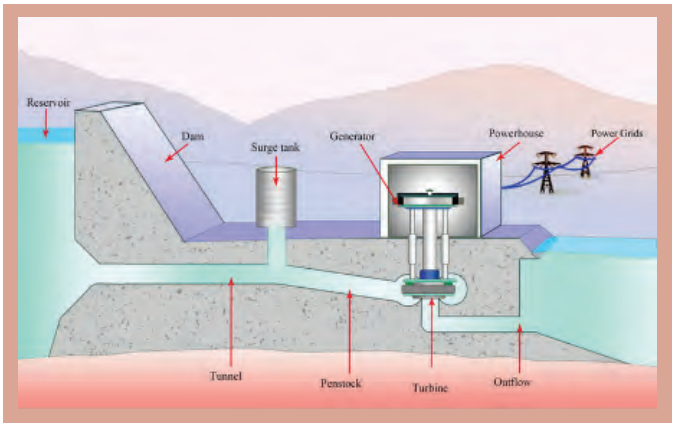
- **Solar Power:** With a cumulative installed capacity exceeding 127 GW, solar is the fastest-growing segment, benefiting from low technology costs and the abundance of high solar irradiation. Flagship schemes like the PM Surya Ghar: Muft Bijli Yojana are rapidly pushing distributed generation (rooftop solar).



- **Wind Power:** Wind capacity is robust at over 53 GW, with a focus on high-potential states and emerging interest in offshore wind projects.



- **Large Hydropower (Hydro):** Contributing approximately 50 GW, large hydro projects are invaluable for providing clean energy and crucial peaking power capabilities, which are essential for balancing the grid when solar and wind generation dip.



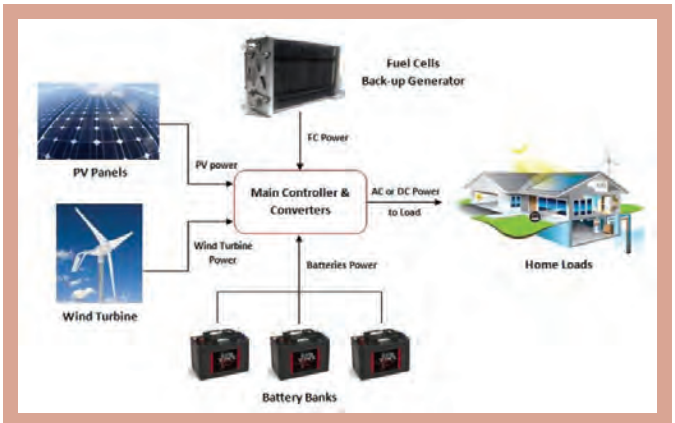
fybros
SMART ELECTRICAL CREATIONS

Where Strength Meets Safety

ARMOR
MINATURE CIRCUIT BREAKER

Engineered for reliability,
ARMOR MCBs safeguard your
spaces from electrical faults
with precision and durability.

For more information visit
www.fybros.com
or call **1800-270-6334**



Hybrid Power Generation System...

The Conventional Backbone (Thermal Power)

Despite the clean energy push, coal-fired power plants (~219 GW) remain indispensable for providing base load power. This continuous, stable power generation is necessary to meet the high and constant demand of industries and ensure grid stability, especially at night. India is focused on modernising this segment by retiring older units and commissioning high-efficiency Supercritical and Ultra-Supercritical (USC) plants to reduce carbon intensity.

Thermal generation remains the largest single contributor to India's electricity supply, serving as the essential base load that ensures continuous and stable power. It accounted for approximately 49% of the country's total installed capacity and around 70-74% of the total generation as of October 2025.

Components and Capacity

Thermal power generation involves converting heat energy from a fuel source into mechanical energy to drive a turbine, which then spins a generator. In India, this category is dominated by coal.

Installed Capacity as of October 2025 (as per CEA)			
Source	**Capacity (approx.)**	**Share of Total Thermal Capacity**	**Role**
Coal	~219 GW	~89%	Base Load: Provides the bulk of continuous power.
Gas	~20 GW	~8%	Peaking & Mid-Load: Provides quick start-up for flexible generation.
Lignite	~6.6 GW	~3%	Base Load: Used near mines, like coal.
Diesel	~0.6 GW	<1%	Emergency/Standby: Used for remote or critical power needs.
Total Thermal	~246 GW	100%	

Major Coal-Fired Power Plants

The thermal sector is characterised by large Super and Ultra Mega Power Projects (UMPPs), mostly operated by the state-owned NTPC Limited (National Thermal Power Corporation) and large private players like Adani Power and Tata Power.

Power Plant	Location	Capacity (approx.)	Operator
Vindhyachal STPS	Madhya Pradesh	4,760 MW	NTPC
Mundra Thermal Power Station	Gujarat	4,620 MW	Adani Power
Mundra Ultra Mega Power Project	Gujarat	4,000 MW	Tata Power

Key Trends and Modernisation

The Indian thermal power sector is undergoing a transformation driven by efficiency and environmental necessity.

Focus on Efficiency and Cleaner Coal

India is prioritising the construction of highly efficient plants to get more power from the same amount of coal while lowering emissions.

- **Supercritical (SC) and Ultra-Supercritical (USC) Technology:** New projects and replacements for older units increasingly utilise USC technology. These plants operate at higher temperatures and pressures, achieving greater thermal efficiency and reducing carbon dioxide (CO_2) emissions per unit of electricity generated compared to conventional sub-critical plants.
- **Expansion Pipeline:** Despite the renewable push, the Ministry of Power (MoP) plans to establish significant new coal and lignite-based capacity to meet peak demand, driven by the slower-than-expected commissioning of new thermal projects in recent years.

Environmental Compliance

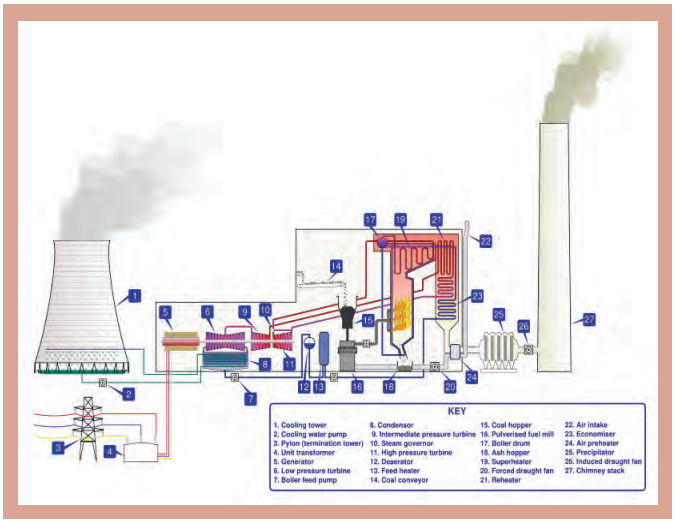
Strict environmental norms are forcing Thermal Power Plants (TPPs) to adopt emission control technology.

- **Flue Gas Desulphurisation (FGD):** Installation of FGD units is mandatory for older TPPs to reduce sulfur dioxide (SO_2) emissions. While implementation has faced delays, it is a major ongoing investment for the sector.

Flexibilisation of Thermal Plants

As more intermittent renewable energy (solar and wind) is added to the grid, TPPs are being forced to change their operational role.

- **Cycling:** TPPs must now operate more flexibly, frequently reducing or increasing their output (cycling)



to balance the grid when solar or wind generation fluctuates. This requirement puts mechanical stress on the equipment and increases operational costs.

- **Gas-Based Generation:** Gas-based TPPs are increasingly brought online quickly during peak demand hours or when renewable generation dips, highlighting their critical role as flexible backup.
- **Challenges in Thermal:** The reliance on thermal power presents significant challenges for India's long-term energy strategy.
- **Coal Supply and Logistics:** Ensuring adequate coal stock, especially during high-demand periods like the summer, remains a recurrent challenge. Efficient logistics and transportation are critical to avoid shortages.
- **Financial Stress:** The aging fleet of TPPs requires significant capital for modernisation and environmental compliance (like FGD installation), straining the financial health of generation companies.
- **Displacement Risk:** In the long run, thermal plants face the risk of economic dispatch down (being run less frequently) as zero-cost renewable energy is prioritised on the grid, threatening the viability of older, less-efficient assets.
- **Gas and Nuclear:** Natural Gas (~20 GW) is used primarily for flexible generation and peaking. Nuclear power (~8.8 GW) is seeing moderate growth, with capacity having increased significantly since 2014 as the government seeks a clean, reliable base load alternative to coal.

Policy and Regulatory Catalysts

The pace of India's energy transition is largely dictated by proactive government policy and strategic regulatory shifts.

- **COP26 Targets:** By surpassing the 50% non-fossil capacity goal well ahead of the 2030 deadline, India has demonstrated its commitment to its Nationally Determined Contributions (NDCs).
- **National Green Hydrogen Mission (NGHM):** This mission is a major strategic pillar, aiming to position India as a global hub for producing and exporting Green Hydrogen. This technology is crucial for decarbonising hard-to-abate sectors (like steel and fertilizer) and offers a long-term, scalable solution for energy storage.
- **Electricity Act, 2003:** This foundational legislation introduced competition, protected consumer interests, and enabled market mechanisms like Open Access, allowing large consumers to purchase power directly from generators, bypassing distribution utilities.

Persistent Challenges in the Power Sector

The sector's growth is hampered by critical financial and technical hurdles that require sustained policy intervention.

Financial Health of Distribution Companies (DISCOMS)

The biggest challenge facing India's power ecosystem lies in the crippling financial losses of the state-owned Distribution Companies (DISCOMS).

- **Aggregate Technical and Commercial (AT&C) Losses:** These losses – caused by power theft, technical inefficiencies in old lines, poor billing, and inadequate collection efficiency – drain the sector's financial health.
- **Regulatory Assets (RAs) and Populist Tariffs:** Discoms often incur losses due to selling power below the cost of procurement, compounded by regulatory delays in approving tariff hikes or recovering outstanding subsidies (Regulatory Assets). This cycle prevents investment in crucial infrastructure upgrades.

Grid Integration and Intermittency

Integrating large volumes of intermittent renewable energy (which generates power only when the sun shines or the wind blows) into the national grid creates technical difficulties.

- **Need for Storage:** To manage this intermittency, massive investment in Energy Storage Solutions is required. Projects involving Battery Energy Storage Systems (BESS) and new Pumped Hydro Storage facilities are being fast-tracked to 'firm up' renewable power and maintain grid stability.
- **Transmission Bottlenecks:** While the Green Energy Corridor project is expanding the transmission network to evacuate renewable power from remote areas to load centers, continued investment is needed to ensure seamless flow and prevent congestion.

The Future: Digitalisation & Decarbonisation

The future of power generation in India will be defined by technological adoption, and a relentless pursuit of the 2070 Net-Zero goal.

- **Small Modular Reactors (SMRs):** Given the urgent need for non-coal base load power, the government is looking at amending the Atomic Energy Act to attract private and foreign investment into the civil nuclear power sector, particularly for new and highly flexible technologies like SMRs.
- **Smart Grid and Digitalisation:** The nationwide rollout of smart meters and advanced grid management systems is essential to reduce AT&C losses, enable two-way communication with rooftop solar producers, and efficiently manage variable power flows.
- **Electric Vehicle (EV) Load Management:** The rise of electric mobility will place a significant new load on the grid. Future planning requires integrating charging infrastructure with smart grids to manage this demand and utilise Vehicle-to-Grid (V2G) technology.

The Indian power sector stands at a pivotal point, balancing unprecedented demand growth with one of the most ambitious clean energy transitions globally. Success will hinge on resolving the financial crisis of the distribution segment while continuing the aggressive expansion and smart integration of renewable and nuclear capacity.

Reshmi Goppi is an Electrical Engineer with PGDM (Executive) in Operations Management from IMT CDL, Ghaziabad. She has 18 years of working experience in Power Sector in large scale Substations and Transmission projects – domestic as well as international. Being a career counsellor, writer and guest speaker, she is connected to many forums.

Dynamic Cables Ltd.

EXPORTING TO OVER
42 COUNTRIES
GLOBALLY

TRUSTED THROUGH INTEGRITY, TRANSPARENCY & SHOWCASING OUR RESPONSIBILITY

39 Years
Of Trust & Reliability

Manufacturer & Exporters of

- 66 KV XLPE Power Cables
- HT & LT Aerial Bunched Cables
- HT & LTXLPE UG Power Cables
- LT PVC Power & Control Cables
- Airdac, Communication & Concentric Cables
- Solar Power Cables
- FR/FRLS/LSZH Cables
- Bare & Insulated Copper Conductors
- Railway Signaling, Power & Quad Cables
- EV Charging Cable
- ACSR, AAA & AA Conductors
- Medium Voltage Covered Conductor

SCAN QR

Supporting MAKE IN INDIA

www.dynamiccables.co.in

"We value the trust our customers place in us..."

***Megger (India) Private Limited** is a trusted manufacturer, trader and supplier of power analysers, automatic battery chargers, measuring instruments & equipment, micro-ohm meters, circuit breakers, resistance testers, testing equipment, drill bits, power supply systems, voltage detectors, digital timers, test jacks, impulse generators, fuse units and others. In an exclusive e-interview with the editorial team of **Electrical India, Ramu Ravichandar, General Manager – Sales, Megger (India),** is focusing on their current offerings in India. Excerpts...*

Could you tell us in brief about the products and services offered by Megger?

Megger is a global leader in electrical test and measurement solutions, supporting the entire electrical value chain from generation to transmission, distribution, and industrial applications. Our portfolio covers a wide spectrum of diagnostic, commissioning, and maintenance tools. This includes insulation testers, protection relay test sets, transformer test equipment, cable fault location systems, partial discharge diagnostics, battery testers, power quality analysers and substation automation tools.

Alongwithproductsolutions,Meggeroffers comprehensive services such as technical training, application consultancy, onsite demonstrations, asset health assessment, and after-sales support. Our focus is to empower customers with reliable tools and deep technical expertise to ensure grid reliability, safety, and long-term asset performance.

What are the flagship products from Megger's power division that are most in demand in India?

In India, the power division sees strong demand for the following flagship solutions:

- **Transformer Diagnostic Equipment:** TTRU3, MTOU3, TAU3 series, Winding Resistance, IDAX (Dielectric Response Analysis), FRAX (Sweep Frequency Response Analyser), Integrated Transformer Test Van for transformer health.
- **Cable Testing & Fault Location Systems:** EZ-Thump, TDRs, Surge Generators, Portable Fault Location system STX40, Van Mounter Fault Location of HV and EHV Cables like CENTRIX, R30. Cable Testing & Diagnostics test systems like VLF62, VLF37, HVDAC for commissioning and predictive maintenance.
- **Protection Relay Test Systems:** The SMRT & SVERKER Relay Kit series, MRCT & MVCT CT PT Analysers, ODEN Series Primary Injection Kits are widely adopted by utilities, generation plants, and EPC companies.
- **Partial Discharge (PD) Diagnostics:** ICM Monitors, GIS Monitors, GIS PDMAR Continuous Monitoring Series, and the advanced handheld PD detection systems for predictive asset monitoring.
- **IPS Software for Asset Performance Management:** These instruments continue to be preferred by utilities for their accuracy, reliability, and ease of use in field conditions.

How has Megger (India) aligned its product and service portfolio to meet the evolving needs of India's transmission and distribution ecosystem?

India's T&D ecosystem is rapidly evolving with a strong emphasis on grid modernisation, asset digitalisation, renewable integration, and reliability enhancement. Megger India has aligned itself by:

- **Focusing on Condition-Based Maintenance**: Offering advanced transformer and cable diagnostics to help utilities shift from time-based to condition-based maintenance.
- **Strengthening Expertise in HV and EHV Assets**: Providing tools specially designed for 220 kV, 400 kV, and 765 kV systems, along with application-specific training.
- **Supporting Digital Utilities:** Expanding offerings in online conditional monitoring, data analytics, and predictive diagnostic tools.
- **Localised Solutions & Faster Support:** Enhancing service infrastructure, local spares availability, and India-focused training programs to improve turnaround time.

Overall, Megger India is working closely with utilities, OEMs, and EPC players to support the nation's grid reliability and infrastructure expansion goals.

Could you talk about some of the recent technological innovations that Megger (India) has introduced (globally or in India) which are particularly relevant for utilities or power companies in India?

Megger has recently introduced several cutting-edge innovations that directly support India's grid modernisation:

- **Advanced PD Monitoring Solutions:** Portable and online systems that combine ultrasonic, UHF, and TEV for comprehensive PD diagnostics in substations and switchgear.
- **Digital Transformer Testing Platforms:** Modernised IDAX, FRAX, and winding resistance analysers with improved analytics, automated reporting, and enhanced insulation modeling.
- **Cable Diagnostics with Smart Analytics:** New generation VLF-TD – PD systems and intelligent fault locators that significantly reduce outage time and improve fault pinpointing accuracy.
- **Motor & Generator Health Tools:** Baker AWA-IV and EXP4000 systems enabling early detection of insulation degradation and mechanical issues in rotating machines.

These technologies help Indian utilities improve asset life, reduce failures, and strengthen operational reliability.

Could you tell us something about your Strategic Partnership with Sentrisense?

Megger's strategic partnership with Sentrisense marks a major step toward digitalising power distribution networks. Sentrisense specialises in IoT-based overhead line monitoring, enabling real-time visibility of conductor sag, temperature, load, vibrations, and weather impact.

Through this collaboration, Indian utilities will benefit from:

- Continuous monitoring of line health
- Early detection of mechanical failures
- Increased power transfer capability
- Faster restoration during storm or weather-related events
- Reduced operational risk and improved network reliability

This partnership supports India's shift toward smart grids, as utilities seek digital technologies that enhance safety, reduce outages, and optimise asset utilisation.

Is Megger (India) planning for any new product launch tailored specifically for the Indian market in the near future?

Yes, Megger is actively exploring India-focused solutions based on customer needs, including:

- Compact test systems for field engineers
- Affordable cable diagnostics for distribution utilities
- Enhanced PD handheld tools

- India-specific training and service packages

Our roadmap includes localised configurations and application tools to support the diverse requirements of state utilities and private EPCs.

How is Megger (India) navigating increasing competition in the electrical and power sector, especially from new manufacturers and localised suppliers?

Megger's approach is centered on technology leadership, application expertise, and long-term reliability factors that go beyond low-cost offerings. Our strategy includes:

- Investing in R&D and continuous innovation
- Providing unmatched accuracy and repeatability in field conditions
- Delivering comprehensive after sales service across India
- Building strong relationships through technical training, seminars, and field support
- Ensuring total cost of ownership remains favourable over the equipment lifecycle

While competition is increasing, customers continue to trust Megger for mission critical testing where precision, reliability, and safety cannot be compromised.

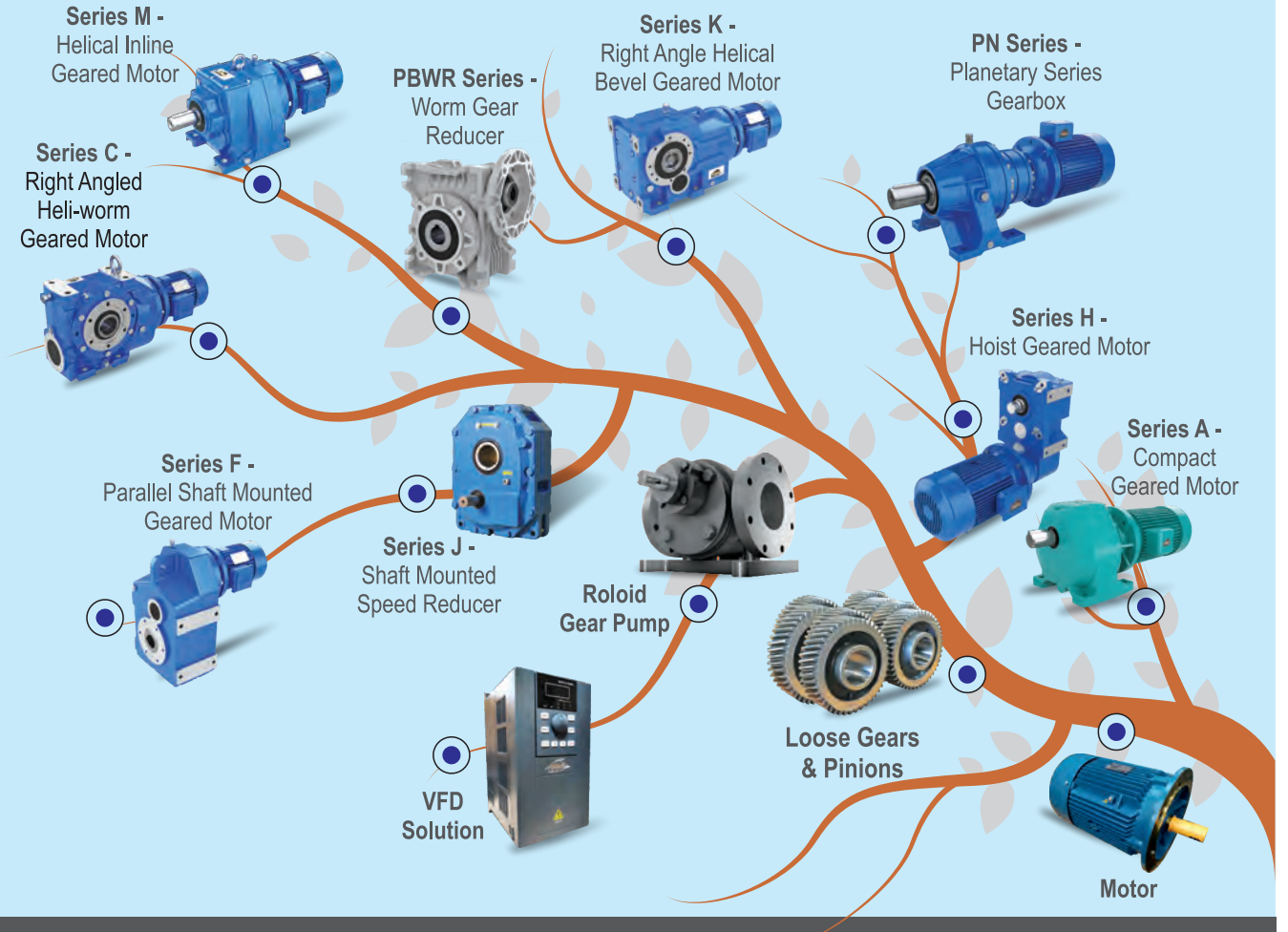
Would you like to say anything to your potential customers?

At Megger, our goal is simple: to help you build a safer, more reliable, and more efficient electrical network. We remain committed to partnering with utilities, industries, EPCs, and OEMs by providing world-class diagnostic tools and technical expertise.

We value the trust our customers place in us and will continue to support you with innovative solutions, reliable service, and a strong commitment to your operational success.

Rooted in excellence. Reaching for the skies.

Like our complete range of innovative products.



At Powerbuild Private Limited, we go the extra mile to serve our customers, literally. With a PAN India network comprising 130 Dealers, 17 Branches and 5 SWIFT Centres, we are never too far from you. So, you can expect prompt and hassle-free service, which will be very rare, thanks to the robust technology and build quality of our products.

GEARED MOTORS | GEAR BOXES | CUSTOMIZED GEARS | DRIVE SOLUTIONS

- Robust design • Modular construction • User-friendly interface • Quick installation
- Economical operation • Easy maintenance

Scan for our LinkedIn page

Phone: +91-2692-231070, 231120, +91-97277-19344 | **Website:** www.powerbuild.in
CIN: U32201GJ1972PTC002065 | **E-mail:** infopbl@powerbuild.in

radicon POWERBUILD

Retrofit Emission Control Devices in DG Systems

This article discusses the operational importance of DG sets, the functioning of RECDs, their efficiency benefits, recent technological innovations, and their contribution toward a greener and more resilient power network...

Diesel Generator (DG) sets remain indispensable to India's electricity grid, ensuring uninterrupted power supply during outages and system contingencies. However, their emissions have emerged as a growing concern under India's tightening air quality framework. The adoption of Retrofit Emission Control Devices (RECDs) allows industries and utilities to maintain grid reliability while meeting environmental compliance.

India's power transmission system demands high reliability. Diesel Generator (DG) sets serve as essential auxiliary power sources that safeguard substations, grid control centres, and communication facilities during interruptions or maintenance shutdowns. Yet, their operation produces particulate matter and gaseous emissions, adding to localised pollution. With the Central Pollution Control Board (CPCB) mandating

installation of Retrofit Emission Control Devices (RECDs) on existing DG sets, it is now possible to sustain reliability while reducing emissions by over 70%.

Role of DG Sets in Grid Reliability

DG sets ensure continuous operation of grid components under various conditions. Their functions are summarised below:

Function	Application Area	Significance in Grid Operations
Auxiliary Supply	Substations, switchyards	Powers control, protection, and communication systems during outages
Black Start	Generation stations	Restores power to auxiliaries to restart generation after total grid failure
Emergency Backup	Load dispatch centres	Prevents data loss, keeps SCADA and telemetry active
Remote Operation	Hilly/Coastal substations	Maintains reliability where grid access is difficult

Environmental and Regulatory Perspective

Diesel exhaust contains fine soot particles, NO_x, CO, and unburned hydrocarbons. These emissions contribute to smog and respiratory hazards. To counteract this, the CPCB (August 2021) notification introduced mandatory RECD installation norms.

Parameter	Requirement / Limit	Remarks
PM Reduction Efficiency	Minimum 70%	Verified through CPCB-recognised testing labs (ARAI/ICAT/FTI)
Backpressure Limit	≤ 30 mbar	Ensures no engine overload
Certification	Mandatory Type Approval	Vendor must hold valid CPCB authorisation
Applicability	All existing DG sets (125 kVA and above)	Nationwide enforcement via SPCBs

Retrofit Emission Control Device (RECD): Structure and Components

An RECD is installed in the exhaust path of a diesel generator to treat emissions before release into the atmosphere.

Component	Function	Pollutant Targeted
Fuel Oxidation Catalyst (FOC)	Oxidizes CO and hydrocarbons to CO_2 and H_2O	CO, HC
Catalytic Soot Trap (CST)	Captures and burns fine soot particles	PM, soot
Selective Catalytic Reduction (SCR)	Converts NO_x to nitrogen and water using urea	NO_x
Ammonia Slip Catalyst (ASC)	Eliminates excess ammonia	Residual NH_3
Crankcase Filter	Prevents oil mist emissions	Oil vapours

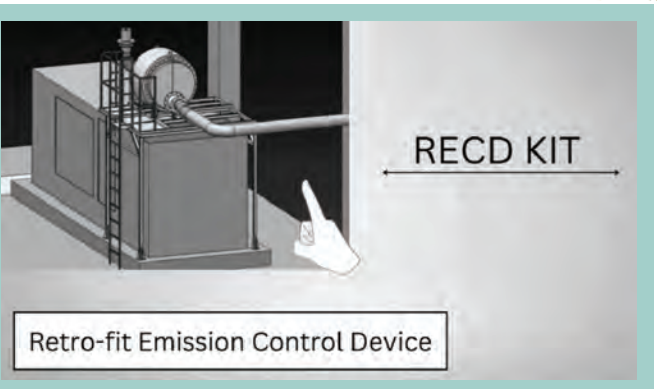


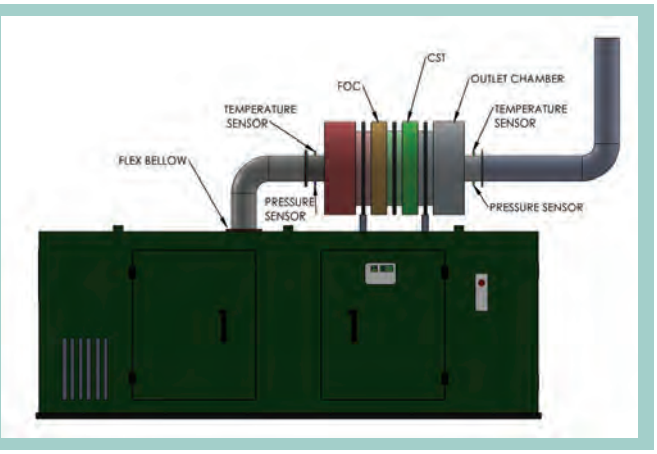
Fig. 1: RECD Kit for DG...

Each unit is designed to meet specific emission profiles without altering the DG's base performance characteristics.

Working Principle

Exhaust gases from the DG engine are passed through multiple filtration and catalytic stages within the RECD:

- **Filtration:** Diesel Particulate Filters (DPF) trap soot and carbon deposits.
- **Oxidation:** The FOC converts CO and unburned hydrocarbons to less harmful gases.
- **Reduction:** In the SCR chamber, injected urea reacts with NO_2 to produce nitrogen and water.
- **Regeneration:** Periodically, trapped soot is burnt off to prevent clogging and maintain flow efficiency.



This sequence ensures compliance with emission standards while keeping generator performance stable.

Energy Efficiency and Operational Benefits

Contrary to the perception that RECDs add only compliance value, they also deliver measurable operational and efficiency improvements.

Efficiency Aspect	Effect / Mechanism	Outcome
Combustion Optimisation	Stabilised exhaust temperature improves combustion	1–3% lower fuel use
Reduced Engine Wear	Cleaner exhaust minimises soot and oil contamination	Longer engine life
Heat Recovery Potential	Exhaust heat reused for air/fuel preheating	Better thermal utilization
Smart Regeneration	Automated filter cleaning reduces idle losses	Maintains consistent performance
Low Backpressure Design	Backpressure within limits prevents overload	Sustains rated DG output

Advances in RECD Technology

Recent developments have improved RECD reliability, compactness, and adaptability.

Advancement	Technical Description	Practical Advantage
Nano catalyst Coatings	Precious metal nanoparticles enable oxidation at lower temperatures	Effective under variable DG loads
Hybrid Filter Media	Combines ceramic and metal substrates	Lower backpressure, longer life
Self-Regenerating Systems	Automatic soot burning using fuel or electric heaters	Reduced manual maintenance
Compact Modular Design	Lightweight, easily retrofitted units for 15–1000 kVA DGs	Flexible installation
Ammonia Slip Catalysts (ASC)	Captures unreacted ammonia from SCR	Cleaner exhaust, full compliance
Digital Twin Simulation	Virtual modelling of exhaust flow and pressure	Optimised system design, less trial error

Implementation Challenges

While technologically proven, certain challenges affect rapid deployment:

- **High Initial Cost:** Particularly for high-capacity DG sets.
- **Maintenance Awareness:** Filter cleaning and regeneration cycles require training.
- **Vendor Authenticity:** Users must verify CPCB certification to ensure compliance.

Capacity building and fiscal incentives could accelerate adoption across public utilities and industries.

Conclusion

In India's evolving power landscape, Diesel Generator sets will continue to serve as the foundation of reliability for grid operation and emergency support. However, environmental performance can no longer be an afterthought.

By integrating Retrofit Emission Control Devices (RECDs), existing DG sets can operate within emission norms, improve fuel efficiency, and align with national sustainability goals. With continuous innovation in catalyst design, filtration materials, and heat recovery systems, RECDs are reshaping how DGs contribute to the energy ecosystem – ensuring that reliability is now coupled with responsibility. EI

Er. Anmol Maharana is the Deputy Manager (Electrical) at Odisha Power Transmission Corporation Ltd. (OPTCL).

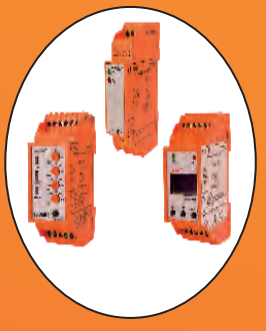
Dr. Sarat Kumar Sahoo is a Professor at the Department of Electrical Engineering in Parala Maharaja Engineering College, Berhampur, Odisha.

Businesses trust minilec®

where it matters the most...

Conforming to Global Certifications

CE UL CERTIFIED RoHS ABS



Phase Failure Relays

Reverse Power Monitoring

Motor / Pump Protection Relays

Follow us on in

Liquid Level Controllers

Alarm Annunciators

Follow us on f

Transducers

Electronic Timers

Automation

www.minilecgroup.com

APAR Industries Unveils "APAR Shakti" Green Wire — A New Benchmark in Safety, Sustainability, and Trust

For more than sixty years, **APAR Industries Limited** has powered India's progress through innovation and reliability. Founded in 1958 with a vision to create world-class conductors, APAR has evolved from a modest power conductor manufacturer into a **global powerhouse** with deep expertise across conductors, specialty cables, polymers, and lubricants.

Today, APAR stands among the leaders shaping the future of the electrical and energy industry:

- Ranked 154th in the Fortune 500 India list
- #1 Global Aluminium and Alloy Conductor Manufacturer
- #1 in India and #3 globally as the Largest Transformer Oils Manufacturer
- #1 in India as an Exporter and #5 Producer of Specialty and Renewable Cables in India
- #1 and the only Indian company offering end-to-end solutions in Copper and Fibre Hybrid Cables
- #1 in India as the largest supplier and manufacturer of Solar Cables
- 5th largest wires & cables manufacturer in the country

APAR's Cable Division supplies high-performance cables to diverse industries, including Indian Defense, Railways (Vande Bharat), and leading data centers like Amazon and Microsoft.

Introducing APAR Shakti – The Green Wire

The newest addition to APAR's cable family, the APAR Shakti – Green Wire, brings together everything the company stands for — safety, sustainability, and superior performance.

Built with 99.97% pure annealed copper and HR-FRLSH insulation (Heat Resistant, Flame Retardant, Low Smoke, Low Halogen), the Green Wire offers unmatched protection against fire, smoke, and toxic emissions. Its balance of high conductivity, mechanical strength, and thermal stability makes it the smart choice for modern electrical environments and most importantly, it's 100% recyclable and completely lead-free.

APAR
Tomorrow's solutions today

What Makes APAR Shakti – Green Wire Stand Out

- **Uncompromised Safety:** HR-FRLSH insulation limits flame spread and smoke output.
- **Sustainability at Core:** Lead-free, RoHS & REACH compliant, and 100% recyclable.
- **Durable Design:** Resistant to abrasion, rodents, and moisture.
- **Superior Conductivity:** 99.97% pure copper ensures high performance and energy efficiency.

Each feature is a deliberate choice — not just to meet standards, but to set new ones.

"Green Wire isn't just another product — it is a statement of purpose, reaffirming APAR's vision to build wiring solutions that light homes, power industries, and preserve the environment for generations to come", said Shashi Amin, CEO – Cable Division (APAR Industries).

More information: E-mail: rohit.budke@apar.com,
Website: www.aparwiresandcables.com

BHARTIA

BCH

Since 1965...

True **10kA**

MCB :

- Breaking Capacity 10kA
- Rating: 0.5A to 5A & 6A to 63A
- Poles: 1P/SPN/2P/3P/TPN/4P
- Tripping Curve B & C
- Conforms to IS/IEC-60898-1 & IS/IEC 60947-2
- IP 20 Degree protection (Finger Proofed terminals)
- Terminal Capacity 35 sq. mm (Cu)

RCCB :

- 25A, 40A & 63A - 2 Pole & 4 Pole
- 30mA, 100mA & 300mA sensitivities

Wires

Distribution Boxes:

- Single Door & Double Door SPN DB
- HTPN Single Door & Double Door DB
- VTPN Double Door DB with MCB Incomer & MCCB Incomer
- Plug & Socket DB
- Double Door Row DB
- 7 Segment Phase Segregated DB
- Phase Selector DB
- One way DB (1P, 2P, 3P & 4P Boxes)

TOUGH | RUGGED | RELIABLE

BCH ELECTRIC LIMITED

Regd. & Corp. office:1105, New Delhi House, 27 Barakhamba Road, New Delhi - 110001, Tel.: +91-11-43673100
E-mail at marketing@bchindia.com or Toll free # : 1800-103-9262, CIN: U31103DL1965PLC425953

www.bchindia.com

An ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018 certified company

"Your trusted EPC Solution provider committed to build a sustainable future through technology & innovation"

DEK & Mavericks Green Energy Limited *is rapidly emerging as one of India's most agile and future-ready EPC partners in the solar domain. In an exclusive interaction with* ***Electrical India, Ajay Rawat, Founder & CEO,*** *shares insights into the company's distinctive approach, its technology-driven execution model, and its bold plans to expand across India and into global markets...*

Could you share the various solar solutions and infrastructure projects that you execute currently?

We are an emerging Solar EPC (Engineering, Procurement & Construction) company specializing in ground-mounted utility-scale solar power projects with experience of about 350+ MWp installed capacity cross India. Our expertise spans the entire project lifecycle — from detailed engineering to commissioning, and operations & maintenance (O&M) thereafter.

What is the USP of DEK and Mavericks? How do you plan to keep up with the competition in this growing industry?

Our unique strength lies in design thinking and supply chain excellence. The two pillars that define our USP and competitive advantage in the solar EPC industry are:

- **Design Thinking Approach:** We believe that a perfectly engineered design is the foundation of an optimized and cost-effective solar solution. Every project we execute begins with a deep focus on technical precision, efficiency, and long-term performance optimization, ensuring maximum energy yield and return on investment for our clients.
- **Supply Chain Expertise:** The promoters of DEK & Mavericks are seasoned supply chain professionals with decades of industry experience. Our strong procurement and vendor management capabilities enable us to source quality materials at competitive costs and ensure timely project execution, even in challenging market conditions.

What role does technology and innovation play in DEK and Mavericks' solar design and engineering process?

At DEK & Mavericks, technology is the backbone of our design and execution excellence. We use advanced solar design and simulation tools for precise engineering, optimized layouts, and accurate energy yield forecasting. To manage complex, large-scale projects efficiently, we've integrated a robust ERP platform that streamlines procurement, scheduling, and site execution, ensuring transparency, cost control, and on-time delivery.

Could you share a recent example of a successful solar farm project that reflects your company's end-to-end expertise?

As such in the journey of accomplishing 350+ MWp installation, we have successfully commissioned many projects of various dimensions. Personally, the one which gives us an immense satisfaction is one 12 MWp project we executed for PM Kusum-C in a remote location in Gujarat. There were complexities in the topography of the land, the transmission line and connectivity was also in the scope of DEK & Mavericks. We are also currently maintaining the plant delivering the committed generation. During the process of execution of this project, the company decided to give back to the village where we executed this project, hence we installed a 3 kw rooftop on the government school totally free of cost.

Every project we execute begins with a deep focus on technical precision, efficiency, and long-term performance optimization...

Are you planning any notable project in 2026?

While DEK & Mavericks is pursuing an aggressive expansion strategy to execute projects across multiple states in India. One of our most promising opportunities lies beyond national borders. Our upcoming project in Botswana, Southern Africa, marks a significant milestone — opening the door to new international markets and positioning us as a globally capable solar EPC player.

Looking ahead to 2026 and beyond, what are some key goals or expansions planned for DEK & Mavericks Green Energy Limited?

We are focused on expanding our portfolio of utility-scale solar farms and integrating advanced energy storage solutions. We're also looking at new geographic markets within India and beyond. The company is committed to explore ways to make solar more affordable & accessible for residential customers. As we grow, we are committed to supporting our team's professional development, ensuring that they are equipped to lead in the clean energy sector. DEK & Mavericks Green Energy Limited, is also aggressively looking for a public issue (IPO) during March 2026.

What are the key qualities that today's business leaders need to succeed in fast-evolving industries like green energy?

Adaptability, agility, fail fast and continual improvement attitude are some the key qualities a leader today needs to imbibe in order to succeed in the fast-evolving industry. Today, every leader irrespective of the industry, need to stay ahead of technological advancements. Leaders today, need to be a collaborator, understand the importance of partnerships to scale up, and create a better ecosystem.

Automation in Power Sector

This article focuses on how modern automation technologies are transforming the power sector by significantly enhancing efficiency, reliability, safety and sustainability across generation, transmission and distribution…

Automation in the power domain signifies the growing application of advanced and intelligent technologies to streamline operations that previously relied on manual intervention. By enabling real-time monitoring, efficient grid management, and optimised energy utilisation, automation enhances productivity, reduces operational costs, improves safety standards, and supports long-term environmental sustainability.

Power sector automation consists of three fundamental processes – data capture, power system monitoring, and power system control – which operate in an integrated and automated manner.

- **Data capture:** This involves the systematic collection of information in the form of measured analogue values of different parameters of power system and binary data of different control devices. This data serves as the foundation for subsequent monitoring, analysing, decision making and control actions.
- **Power system monitoring:** It is undertaken by field personnels and maintenance engineers who analyse the collected data either remotely, through computer-based interfaces and visual displays, or near the equipment site using local-panel indicators and portable computers.
- **Power system control:** This translates to the transmission of actionable signals to various devices within the network of components designed to monitor, regulate and safeguard the overall power infrastructure.

As power networks expand in size and complexity, with an increasing number of power sources and control devices distributed across extensive and sometimes challenging geographical areas, the need for centralised monitoring and management becomes critical. For large-scale national grids as well as microgrids, centralised access to information regarding the status of the grid and its equipment,

along with the capability for remote control and maintenance of the grid, customers, and different power sources, can be effectively achieved through the application of information technology. This leverages advancements in computational power, data storage, high-speed communication, and the integration of diverse technological solutions. Key areas of focus include customer engagement, Information Technology (IT) transformation, Operational Technology (OT), and the management of work and asset value. The framework responsible for monitoring and controlling power grid is commonly referred to as the Distribution Automation System (DAS).

The purpose of automation goes beyond merely substituting human labour, it aims to optimise system performance, enhance reliability, and achieve a level of precision that cannot be consistently attained by humans. Furthermore, automation significantly strengthens safety by reducing ecological health hazard. In addition, a substantial portion of tasks related to scheduling, billing, and account management in many organisations have already been automated.

Several technologies are key drivers of automation in the power sector:

- **Supervisory Control and Data Acquisition (SCADA) Systems:** They enable local and remote monitoring and control of power system network.
- **Artificial Intelligence (AI) and Machine Learning (ML):** Those study a plethora of information to optimise energy generation, distribution, and consumption.
- **Robotics:** They conduct maintenance, repairs, cleaning of solar panels, and inspections in hazardous or hard-to-reach areas.
- **Drones:** Facilitate inspection of power lines, pipelines, and other critical infrastructure.

Several technological solutions are considered instrumental for the development and modernisation of power systems. These include hybrid and digital substations, High Temperature Low Sag (HTLS) conductors to improve power flow within limited RoW, helicopters and Unmanned Aerial Vehicles (UAVs) facilitate route surveys, construction, and monitoring of transmission lines. Advanced technologies such as Voltage Sourced Converter (VSC)-based HVDC systems, Phase Shifting Transformers (PST), grid-forming inverters, Dynamic Line Rating/Loading, and travelling wave fault detectors further contribute to the efficient and reliable operation of modern power networks.

Dynamic Line Rating (DLR)

Dynamic Line Rating (DLR) is a Grid-Enhancing Technology (GET) that determines the real-time power capacity of transmission lines using live environmental data as well as real time measurement of sag of the transmission line through sensors.

To effectively implement Dynamic Line Rating (DLR), it is essential to integrate advanced sensors and monitoring systems within transmission and distribution networks. These systems, installed on or near the lines, continuously record instantaneous environmental and operational data such as: wind speed, ambient temperature, solar radiation, circuit loading, line status, conductor temperature and ground clearance.

The collected data is transmitted to a central control system through communication interface, where it is analysed to support informed operational decisions, including efficient thermal load management and enhanced line performance.

This maximises the use of existing grid assets, enhances reliability, and defers costly infrastructure upgrades. In turn, DLR supports lower electricity costs, quicker integration of different energy resources, and higher inclusion of Variable Renewable Energy (VRE) in the grid ensuring safety and compliance with the statutory norms.

For instance, strong winds help cool transmission lines, allowing them to carry more electricity safely. Primary data from field, when applied to technical standards such as IEEE 738 and CIGRE TB498, generate static line ratings. These data can be further refined into predictive forecasts using algorithms that integrate statistical analysis, modelling techniques, and dynamic weather data. Such analysis enables the system to anticipate the line's capacity at any moment, allowing operators to safely increase power flow beyond static limits when conditions are favourable.

Certain Dynamic Line Rating (DLR) systems can forecast line capacity up to 72 hours ahead, aiding in effective grid planning and operation. By utilising favourable weather conditions, DLR can boost the power-carrying capacity of existing transmission lines – sometimes by as much as 200%. However, implementation must be approached cautiously to prevent new operational risks and to account for

existing system constraints. Substations or lines may get damaged by natural or human-induced events, a robust grid can redirect power through alternative routes. With accurate short-term and day-ahead forecasting, DLR can also assign 'emergency' ratings to in-service lines, helping maintain system reliability during contingencies.

Advantages of Automation

- **Fault prediction:** By integrating AI with sensors, equipment can be continuously monitored to detect issues before failure occurs, reducing downtime, costs, and risks while improving safety and efficiency.
- **Maintenance facilitated by image processing:** Globally few electricity grids use drones provided with high-resolution and infrared cameras to check temperature of transmission lines and pylons. This image-based maintenance allows efficient fault detection across large and hard-to-reach areas.
- **Energy efficiency determination:** Smart devices like Google Home, Amazon Alexa and Nest – let users monitor and control home energy use. AI-enabled meters can also optimise consumption and storage, improve demand and generation forecasts, and support renewable integration, reducing reliance on fossil-fuel backup systems.
- **Disaster recovery:** By predicting power availability and prioritising delivery, AI can accelerate recovery while minimising system strain. Additionally, rapid access to imagery and data allows for faster damage assessment and more informed decision-making within the critical hours following a disaster.
- **Utility theft management:** Unauthorised connections and consumption pose a major challenge in the power sector. AI can detect them by analysing usage patterns, payments, and other data, and when paired with smart meters, it enhances monitoring and reduces the need for costly physical inspections.

Communication – Back Bone of Automation

Communication in power sector automation refers to the communication systems and technologies that enable efficient, reliable, and intelligent two-way communication between components of modern electrical grids. The evolution from conventional power grids to smart grids is characterised by the integration of electrical power systems with advanced Information and Communication Technologies (ICT), resulting in automated, widely distributed energy delivery networks capable of monitoring and responding to changes from power plants to individual appliances.

Smart grid communication technologies comprise of both wired and wireless systems. Wired technologies include Fiber optics and Power Line Communication (PLC). Wireless technologies used in smart grids include Wi-Fi, cellular networks such as LTE and 5G, and cognitive radio systems. Commonly used methods to transport data are PLC, IP/Ethernet, LPWAN, MPLS, etc. These technologies are used for different applications based on their suitability for coverage, latency and other supporting environment and protocols. Communication protocols include IEC 61850, TCP/IP (Transmission Control Protocol/Internet Protocol), DNP (Distributed Network Protocol), MQTT (Message Queuing Telemetry Transport). Core applications and services dependant on this communication system are protection, metering, SCADA, predictive maintenance, etc.

Challenges in Way of Automation

While AI offers significant opportunities to enhance power distribution and consumption, transmission, and generation, it still faces challenges related to efficiency, transparency, affordability, and the amalgamation of renewable energy into power systems.

Traditional grid infrastructure in rural regions often suffers from deferred maintenance and outdated technology. Rural regions often suffer from limited or non-existent broadband internet access and cellular coverage. Transitioning to a smart grid necessitates substantial upfront investment in Advanced Metering Infrastructure (AMI), communication networks, and grid automation technologies. The challenge lies in demonstrating a viable return on this investment, particularly when serving a smaller customer base spread across vast distances.

As internet use and IT capabilities continue to expand, cybersecurity has become a critical concern for authorities. The increasing integration of operational and information systems, supported by smart technologies and cloud-based real-time data, has heightened exposure to cyberattacks, hacking attempts, and system malfunctions that could disrupt normal operations. Such malicious intrusions can endanger power supply and compromise overall grid security. In particular, False Data Injection (FDI) attacks have emerged as a newer and more severe threat to smart grid cybersecurity.

Way Forward

India's fast-growing power sector presents substantial

opportunities for innovation across both technical and operational domains. However, it also challenges engineers and researchers with tasks such as managing bulk power transmission from distant regions, safeguarding grid security, and tackling environmental impacts.

To meet rising demand, the transmission system must expand through measures such as implementing high-capacity long-distance HVDC and HVAC systems, deploying Flexible AC Transmission Systems (FACTS) devices like STATCOM, SVC or Thyristor Controlled Series Capacitor (TCSC) on 400 kV and 220 kV lines where feasible. Other initiatives include developing smart transmission grids, overlaying 765 kV AC lines on existing 400 kV networks, equipment for 1200 kV and 765 kV AC systems, FRP cross arms or composite insulator cross arms, and high-temperature conductors for transmission lines. Efforts also focus on designing seismic-resistant substations, conducting pollution and lightning mapping studies, creating centralised data repositories, and implementing automated Emergency Restoration Systems (ERS). Additionally, demand-side measures can help reduce grid congestion, a key factor in system management costs.

A smart grid is essentially a digital enhancement of the power distribution network, designed to improve operational efficiency and support the integration of alternative energy sources. Other key areas such as Computer aided monitoring and control of Smart Distribution Transformers, Customer level intelligent automation system, Data communication system for Distribution Automation, Substation and feeder level automation, Distribution Control Centre (DCC) software, greater Substation and Feeder Level Automation, Smart Metering, Intelligent Electronic Devices (IEDs), are to be developed and deployed.

The Central Electricity Authority (CEA) released the "CEA (Cyber Security in Power Sector) Guidelines 2021," in October 2021, providing a roadmap for enhancing cybersecurity in the power sector. Now incorporated into the Indian Electricity Grid Code (IEGC) 2023, these

guidelines help power companies safeguard the operational integrity and fault tolerance, mitigating cyber risks.

Global Initiatives

The Digital Demand-Driven Electricity Networks (3DEN) initiative is a joint effort by the International Energy Agency (IEA), the United Nations Environment Programme (UNEP) and the Italian Ministry of Environment and Energy Security. It aims to accelerate power sector modernisation through digitalisation, smart grid technologies, and demand-side resource management, leading to greater reliability, affordability, and inclusivity for households, communities, and businesses. As part of the initiative, the IEA will draw on global analysis, reports, and best practices to develop and share practical tools and guidance.

During its first phase (2020–2024), the programme emphasised analytical studies, the creation of regulatory frameworks, and pilot projects to advance the adoption of digital energy technologies. Key focus regions included Colombia, Indonesia, India, Brazil, Tunisia, South Africa, Morocco, as well as countries across ASEAN, Africa, and Latin America.

Pilot projects carried out in Colombia, Brazil, India and Morocco achieved significant outcomes. They strengthened electricity reliability for over 320,000 beneficiaries, covering low-income households, small enterprises, and key community services like schools and healthcare facilities. The projects helped avoid nearly 3,800 tonnes of CO_2 emissions annually through renewable integration, improved profitability, and customer-driven flexibility, while deferring close to USD 60 million in infrastructure investments by harnessing digital capabilities. They also enhanced active demand, reduced downtime, and digitised more than 60 GWh of industrial operations. Over 650 people were trained and engaged in deployment and E-participation, building local capacity to ensure viability of these solutions. Additionally, the projects enabled testing of innovative business models that demonstrated both financial and energy efficiency benefits from digitalisation.

In India, the consortium collaborated with Panitek Power and The Energy and Resources Institute to develop a digital twin for electric distribution grids. This innovation improved operational reliability, enhanced outage management, and lowered costs for around 20,000 consumers.

These pilot projects highlight the quantifiable operational benefits through digitalisation in improving system efficiency, consistency, and endurance, particularly within rapidly evolving energy systems.

Tata Consulting Engineers Role in Automation

Tata Consulting Engineers (TCE) uses its strong engineering background and digital technology to offer complete solutions around the world. For more than sixty years, TCE has handled complex projects in areas such as power plants, smart cities, infrastructure, and major landmarks.

Tata Consulting Engineers Limited (TCE) offers a complete end-to-end Dynamic Line Rating (DLR) solution that turns conventional power grids into dynamic, intelligent systems. TCE has successfully implemented India's first 400 kV DLR project, demonstrating its strong expertise and leadership in the Indian power sector. This is a proven, fully operational solution already delivering measurable value.

Other services offered include 3D engineering, 4D and 5D simulations, Building Information Modelling (BIM), asset digitalisation and information management, as well as product engineering and turnkey machine development.

Conclusion

Implementing energy efficiency measures is generally faster than building new generation or grid infrastructure. When combined with advanced data analytics, smart-grid technologies enhance the integrity and competence of electricity networks. The large and complex datasets produced are well-suited to AI and machine learning, which can support fault detection, power quality monitoring, predictive maintenance, and predicting generation of renewable energy. Advances in ICT, big data, distributed computing, and AI have driven the growth of smart metering, generating vast amounts of data at high speed.

Power utilities should adopt a proactive approach to resilience against hazards like extreme weather, wildfires, and cyber threats. This involves creating resiliency roadmaps with weather forecasts, fire and flood modelling, real-time sensors and cameras, and continuous situational awareness. Cybersecurity assessments are particularly critical for new devices, systems, and service providers. EI

Sandhya Mukherjee; a graduate in Electronics and Power from Visvesvaraya National Institute of Technology, Nagpur; has been in Power Sector with experience of design engineering, consulting, quality management and operations of thermal power station. Presently, she is working in Technology Vertical of Tata Consulting Engineers Ltd., in the role of Assistant General Manager.

Synthesis

Engineered for Excellence

Foil LV Coil Winding Machine from Synthesis

Synthesis Winding Technologies provides advanced coil winding machines known for precision, automation, and proven reliability. From transformers to industrial electronics, every product reflects decades of expertise and a commitment to quality.

30 years of **Experience** | **10000+** machines running in **40 countries**

+91-80- 30282020/35/36 synthesis-winding.com

No 14/A, Shantipura Road Electronics City Phase II, Bengaluru

info@synthesis-winding.com

Gloster Cables Limited (GCL) *was incorporated in 1995. Over the past 25 years, the company has made remarkable advancement in its infrastructural capacities and market reach. In an exclusive e-interview,* ***Vinay Rathi, Director,*** *of the company is fielding questions from the editorial team of Electrical India. Excerpts…*

Gloster began with a turnover of Rs. 5 crore and has now set sights on Rs. 1,000 crores. What strategic initiatives or market segments are enabling this ambitious growth?

Gloster's journey from a Rs. 5 crore turnover to a target of Rs. 1,000 crore is underpinned by a clear focus on specific market segments. We have established ourselves as a dominant player in the power cable field in India, and our strategic initiatives are built on this foundation. Our pan-India marketing network and a strong reputation for product quality and service are key drivers. We are also pursuing international expansion and innovation.

You have added a diverse portfolio, including fire survival, solar, instrumentation, and signaling cables. What drove these expansions, and how

are you anticipating future product needs?

Our expansion into a diverse portfolio of fire survival, solar, instrumentation, and signaling cables was driven by market needs and a commitment to innovation. We're aligning with major infrastructure projects, and our focus on safety has led to a high demand for our fire survival cables. We're anticipating future needs by monitoring government initiatives and technological shifts, ensuring we stay ahead in key segments like renewable energy and smart infrastructure.

With experienced leaders guiding the company, how do their knowledge and your team's expertise help in making important decisions and bringing new ideas?

The synergy between our experienced leaders and our team's expertise is the engine of our decision-making and innovation. Our leaders provide invaluable strategic vision and a deep understanding of the industry, drawing on decades of experience to navigate challenges and identify opportunities. This is complemented by our team's specialised knowledge in areas like manufacturing, R&D, and market trends, which provides real-time data and creative solutions. This collaborative approach ensures we make informed decisions and constantly bring new, market-relevant ideas to life.

Gloster emphasises on quality with safety, zero halogen fire-resistant cables, and sustainability. How do these values inform your R&D and market approach?

Gloster's emphasis on quality, safety, and sustainability is the core of our R&D and market approach. We have invested in advanced manufacturing processes like triple extrusion to ensure the highest quality. Our focus on safety drives our development of products like zero halogen fire-resistant cables, which meet stringent international standards.

We are also committed to sustainability, and our R&D efforts are focused on creating products and processes that minimise environmental impact. This unwavering commitment to these values has helped us earn the trust of our customers and establish ourselves as a reliable brand in the market.

Control Panels in the Indian Power Sector

Control panels are vital in the Indian power sector for ensuring safety, improving operational efficiency and reliability, and managing power distribution. They act as the 'brain' of electrical systems, containing components like circuit breakers and switches to protect against faults, automate processes, and allow for seamless integration of renewable energy sources. This ensures a stable and efficient supply of electricity while minimising human error and downtime...

India's power sector stands as one of the world's most complex and rapidly evolving energy ecosystems. With a peak demand exceeding 250 GW and ambitious renewable energy targets, the nation's electrical infrastructure requires sophisticated control systems to ensure reliable, safe, and efficient power delivery. At the heart of this vast network lie control panels, the critical yet often under-appreciated components that serve as the nerve centres of electrical systems across generation, transmission and distribution networks.

The Foundation of Modern Power Systems

Control panels represent far more than mere electrical enclosures; they are sophisticated interfaces that bridge the gap between human operators, complex machinery, and advanced digital systems. These systems perform four fundamental functions that are essential to modern power operations:

- **Operational Control:** This forms the primary function, enabling the switching, starting, and regulation of critical equipment including motors, generators, and transformers. This capability ensures that power systems can respond dynamically to changing demand patterns and operational requirements.
- **Protection Systems:** They are housed within control panels provide the first line of defence against electrical faults and equipment failures. Through protective relays, circuit breakers, and isolators, these systems safeguard expensive infrastructure and prevent cascading failures that could impact large portions of the grid.
- **Monitoring and Diagnostics:** These capabilities have become increasingly sophisticated, incorporating real-time data collection on voltage, current, frequency, power factor, and overall system health. Modern panels integrate seamlessly with SCADA systems, providing operators with comprehensive visibility into system performance.
- **Automation Functions:** These represent the cutting edge of control panel technology, enabling automatic switching, load sharing, synchronisation, and fault management through programmable logic controllers and advanced communication protocols. This automation is crucial for managing the complexity of modern power systems, particularly as renewable energy sources introduce new variability challenges.

Diverse Applications Across the Power Value Chain

The Indian power sector employs a sophisticated array of control panel types, each optimised for specific applications within the electricity value chain.

- **Power Control Centers (PCCs):** These serve as centralised command units for managing large electrical loads across thermal, hydro, nuclear, and renewable generation facilities. These robust systems house circuit breakers, protective relays, precision meters, and bus-bar arrangements designed to handle high fault levels while ensuring continuous power supply to critical equipment such as boilers, turbines, and auxiliary systems.
- **Motor Control Centers (MCCs):** These form the operational backbone of industrial plants, refineries, and generation auxiliaries. These systems control and protect motor-driven equipment including pumps, conveyors, blowers, and compressors. Modern MCCs increasingly incorporate Variable Frequency Drives (VFDs) to enhance energy efficiency, directly supporting India's Bureau of Energy Efficiency initiatives.
- **Generator Control Panels (GCPs):** These manage the complex task of synchronisation and load sharing among multiple diesel generator sets. Equipped with automatic transfer switches, these panels ensure seamless power transitions during grid outages, making them indispensable for hospitals, data centres, metro systems, and other mission-critical infrastructure.
- **Relay and Protection Panels:** They are integral to grid-scale substations, managing transmission voltages from 66 kV to 765 kV across India's high-voltage network. These sophisticated systems incorporate numerical relays with advanced protection functions including distance protection, overcurrent detection, differential protection, and under-frequency relays, playing a vital role in maintaining system reliability amid the growing variability introduced by renewable energy sources.
- **Synchronising Panels:** They have gained prominence in facilities where multiple power sources must operate in harmony. These systems synchronise voltage, frequency, and phase sequence between grid power, diesel generators, and renewable sources, preventing system instability. Their adoption has accelerated across metro rail projects, airports, data centres, and large commercial developments.
- **Instrumentation and SCADA Panels:** These form the digital backbone of modern substations and generation facilities. Housing programmable logic controllers, remote terminal units, Ethernet

switches, and human-machine interfaces, these panels enable comprehensive remote monitoring and control capabilities, supporting initiatives like Power Grid Corporation's Digital Substation mission.

Regulatory Framework and Standards Compliance

The critical nature of power infrastructure demands strict adherence to comprehensive technical standards and regulatory requirements. Control panels in India must conform to multiple layers of specifications:

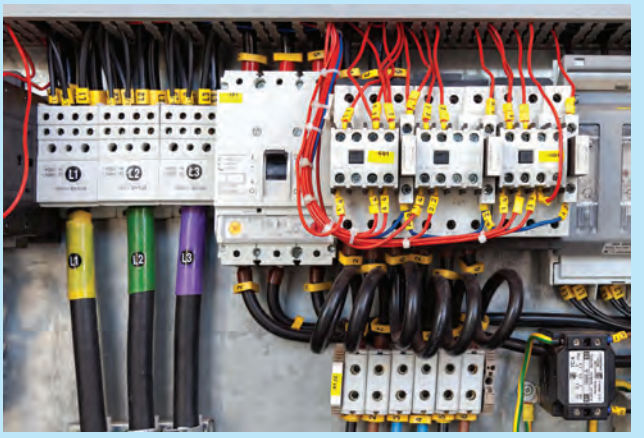
International standards including IEC 61439 and its Indian equivalent IS/IEC 61439 govern low-voltage switchgear and control gear assemblies, ensuring global compatibility and reliability. The Indian standard IS 8623 specifically addresses requirements for factory-built assemblies, while the Central Electricity Authority guidelines establish safety protocols for electrical installations.

Additional regulatory oversight comes from IE Rules and CERC/SERC regulations, which impose strict protection requirements for grid-connected panels. Leading manufacturers address these requirements through advanced design features including IP protection ratings up to IP65, arc-proofing capabilities, type-tested assemblies, and sophisticated fire detection systems.

India's Manufacturing Excellence

India has developed a robust control panel manufacturing ecosystem that serves both domestic needs and international markets across Africa, the Middle East, and Southeast Asia. This manufacturing strength rests on several key pillars:

- **Local Value Addition:** This has been significantly enhanced through Make in India initiatives, with indigenous component manufacturing reducing dependency on imports while building local technical expertise. This localisation strategy has improved supply chain resilience while reducing costs for domestic projects.
- **Customisation Capabilities:** These represent a particular strength of Indian manufacturers, who have developed flexible design approaches that can accommodate diverse project requirements ranging from small-scale industrial applications to ultra-high-voltage substations.
- **Automation Integration:** This has accelerated through strategic partnerships between Indian



panel manufacturers and global automation leaders including Siemens, ABB, Schneider Electric, and L&T. These collaborations bring cutting-edge technology to Indian projects while building local technical capabilities.

- **Testing Infrastructure:** These provided by institutions like the Central Power Research Institute ensures that Indian-manufactured panels meet international standards through comprehensive type-testing and certification programs.

Technological Innovation and Digital Transformation

The evolution of control panels from simple switchgear enclosures to intelligent, connected systems reflects broader digitalisation trends across the power sector. Key technological advances include:

- **Digital Integration:** This means integration through numerical relays, smart meters, and IoT sensors that feed real-time data to cloud-based analytics platforms, enabling predictive maintenance and optimised operations.
- **Enhanced Safety Systems:** These include arc-fault detection and mitigation technologies that significantly improve operator safety in high-risk environments.
- **Modular Design Philosophy:** This maximises space efficiency in urban substations and renewable installations where real estate constraints are significant.
- **Cybersecurity Integration:** This addresses the growing threat landscape as SCADA-integrated panels become more connected and potentially vulnerable to cyber attacks.
- **Energy Efficiency Features:** These include advanced motor starters and drives that minimise

electrical losses in industrial environments, directly supporting national energy efficiency objectives.

- **Predictive Analytics:** These leverage artificial intelligence algorithms to anticipate equipment failures before they occur, reducing downtime and maintenance costs.

Enabling India's Renewable Energy Transition

Control panels play an increasingly critical role in India's renewable energy sector, which has become the fastest-growing segment of the country's power mix. In solar power installations, specialised panels manage DC-AC conversion processes, inverter interlocking systems, transformer protection, and comprehensive SCADA-based monitoring.

Wind energy applications require sophisticated motor control centres and relay panels that protect induction generators while controlling complex yaw and pitch mechanisms that optimise turbine performance. Hybrid renewable projects present particularly complex challenges, requiring synchronising panels that can seamlessly integrate solar, wind, and battery energy storage systems with existing grid infrastructure.

As India pursues its ambitious target of 500 GW renewable capacity by 2030, control panel manufacturers face unprecedented opportunities to develop cost-effective, digitally enabled, and environmentally sustainable solutions tailored to renewable energy applications.

Challenges and Future Outlook

Despite significant progress, several challenges continue to impact control panel deployment in India. Market fragmentation, with numerous unorganised players supplying substandard products, threatens system reliability and safety. Skill gaps in smart panel design and integration limit the industry's ability to fully leverage available technologies.

The future trajectory of control panels in India will be shaped by the convergence of digitalisation, localisation, and sustainability imperatives. Digital substations will drive universal adoption of intelligent electronic devices and communication-enabled panels. Energy storage control systems will require sophisticated panels capable of managing grid-scale battery installations.

Environmental considerations will promote green manufacturing practices using recyclable materials and low-carbon production processes. Control panels will

evolve into integrated command platforms for distributed energy resources, while regulatory frameworks will impose stricter standards for power quality and safety.

Conclusion

Control panels may not capture public attention like solar parks or smart meters, but they represent the essential foundation of India's power sector transformation. From ensuring grid reliability to enabling renewable energy integration, these systems embody the intersection of engineering precision, operational safety, and digital intelligence. For manufacturers, engineers, and policymakers, investing in advanced, standardised, and future-ready control panels is not merely a technical decision – it is a strategic imperative for powering India's continued economic growth and energy security.

Karn Pallav is a qualified Mechanical Engineer and MBA (Power) graduate from NPTI Faridabad. He is currently working as the Head (Regulatory Affairs) in a leading power DISCOM at New Delhi. He has around two decades of management experience in the entire value chain of the Power Sector. He has vast experience in power utilities dealing with competition issues, tariff determination, licensing and other techno-commercial matters. Being an engineer and Power Manager, he is also interested in technical issues related to Conventional and Renewable Generation, Open Access, Parallel License Regime, Smart Grid, AMI, Smart Meters, Cyber-Security Issues and E-Mobility. He has also written five books, namely – 1) The Power of Positive Thinking, 2) Customer Engagement Strategies in Retail Electricity Market, 3) 5 Rules For Life, 4) Whispers of the Heart and 5) Whispers of the Himalayas.

Honda's Plans for the Second Half of 2020s

Honda Motor Co., Ltd., has recently held the Honda Automotive Technology Workshop for members of news media. Here is a summary of the company's next-generation technologies for automobile products scheduled to go on sale in the second half of the 2020s...

Next generation hybrid study model...
Image Courtesy: Honda Motor Co., Ltd.

Key technologies introduced by Honda Motor Co., Ltd., at the workshop included: i) the platform for next-generation hybrid models, ii) hybrid-electric system technologies for new large-size hybrid models scheduled to be launched in North America in the second half of the 2020s, and iii) key technologies to be applied to the production model of a compact EV based on the Super-ONE Prototype, which made its world debut at the Japan Mobility Show 2025.

Honda positions the 'environment' and 'safety' as priority issues that need to be addressed in order for Honda to continue offering the joy and freedom of mobility to people in a sustainable manner. Based on this belief, Honda has set ambitious goals of achieving 'carbon neutrality for all of its products and corporate activities' and 'zero fatalities from traffic collisions involving Honda motorcycles and automobiles', globally by 2050.

As announced at the 2025 Honda Business Briefing held in May of this year, Honda is working to further strengthen the competitiveness of its Electric Vehicles (EV) and Hybrid-Electric Vehicles (HEV) and offer new value to customers through electrification and enhanced application of intelligent technologies.

In the meantime, Honda will continue to pursue its value proposition in the electrified era: the 'joy of driving' experienced by the driver while driving with a sense of oneness with their vehicle. Regardless of powertrain type, EV or HEV, Honda will continue to build its products based on the Honda M/M Concept, a human-centric approach to Honda car design, and pursue the 'joy of driving', offering comfort and fun not only to the driver but to all occupants.

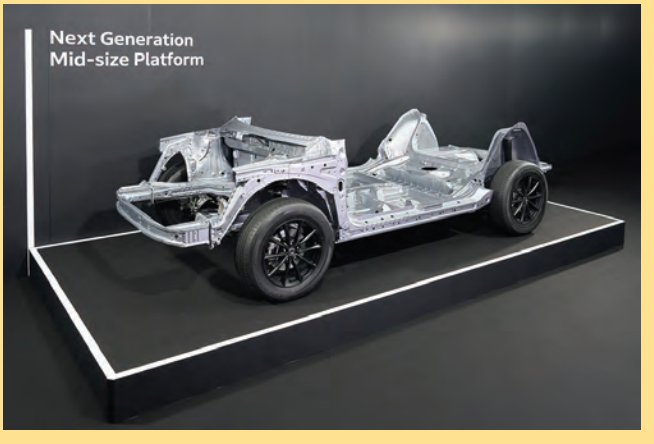
The 'man maximum, machine minimum (M/M)" concept is a basic approach to Honda car design to increase the efficiency of the vehicle interior by maximising space for people and minimising the space required for mechanical components.

Under the concept of 'Enjoy the Drive' which represents the value proposition of Honda automobile products, which is centred on the M/M Concept and the 'joy of driving', Honda will remain committed to making steady advancements of next-generation automotive technologies. At the workshop, Honda unveiled new technologies being developed to embody the unique approach and value system of Honda.

Overview of the next-generation mid-size platform

Honda is further advancing all aspects of its hybrid system and the HEV platform, with a plan to start adopting them from a group of next-generation HEV models to be introduced to market from 2027 onward.

The next-generation platform is being developed by combining various innovative technologies to realise both high body rigidity and lightweight at a high level and a modular architecture that enables greater parts



Next generation mid-size platform...

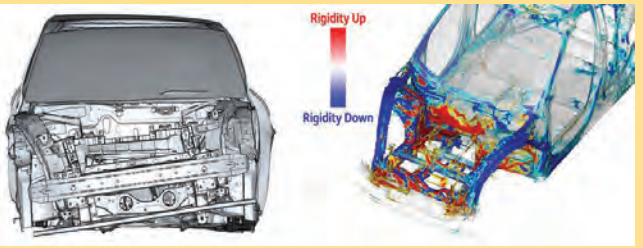


Image of the new approach to body rigidity management to enhance driving stability...

commonality. This will further enhance the 'joy of driving' unique only to Honda, enabling the driver to enjoy a sporty and exhilarating driving experience.

As a new benchmark for driving stability, which directly influences the vehicle dynamic performance, Honda established a new approach to body rigidity management that enhances driving stability. By optimising the body rigidity, the body weight will be reduced. At the same time, by generating vehicle behaviour as if the body flexes during cornering, the load put on each tire will be controlled to improve roadholding performance. As a result, the next-generation EVs will realise an unprecedented level of driving stability and a sporty and pleasant driving experience. Honda is planning to apply this technology to its EV platform as well.

The weight of the HEV platform was reduced by 90 kg (198 lbs.) compared to the current platform by revising the body structure and adopting new engineering design methods. With this next-generation platform, Honda will strive to create new HEV models that will realise both the fun of driving and excellent fuel economy.

The modular architecture that achieves a high percentage of parts commonality across various models was adopted. By separating commonised modules, such as the engine room and rear underbody, and unique modules such as the rear cabin, the efficiency of new model development will be increased. Honda is aiming for parts commonality of more than 60% across all models using this platform, which will enable the efficient production of distinctive and diverse models while keeping cost down. As a result, the efficiency of both development and production will be significantly increased.

In line with the advancement of the platform, technologies to enable vehicle control at the will of the driver are being adopted, such as a Motion Management System that leverages posture control know-how Honda amassed through the development of original robotics technologies. Moreover, a new pitch control technology (A technology that controls deceleration G in accordance with steering input to increase the load put on the front wheels, thereby increasing the grip of the front wheels.) will be added to Agile Handling Assist an electronic control system that supports smooth vehicle behaviour during cornering, and is already adopted to the current Accord and Prelude – to help the driver control the vehicle exactly as intended in all driving situations unaffected by road conditions. Through these technologies, Honda will strive to further enhance the 'joy of driving' for its customers.

Overview of the next-generation large-size hybrid system

As market demand for HEV models continues to grow, Honda positions its HEV models, especially the next-generation models scheduled to go on sale in 2027 and beyond, as a core group of products, which will play key role during the transitional period leading up to the full-fledged popularisation of HEVs.

Especially in the North American market, which will be the main market for HEV models, there will continue to be solid demand for large-size HEVs. To fulfil such demand, Honda is developing a next-generation hybrid system featuring powerful driving performance and high towing capacity, as well as outstanding environmental performance, befitting large-size HEVs in the D-segment and larger, with product launches in the second half of the 2020s.

At the workshop, Honda unveiled key technologies of its next-generation large-size hybrid systems, including a newly developed V6 engine that complies with stringent environmental regulations, as well as newly developed

Next generation large-size hybrid system...

drive units and battery pack that achieve both high efficiency and low cost.

Honda is striving to improve the fuel efficiency of its next-generation large-size HEV models by more than 30% compared to the ICE models currently being sold in the same segment. To this end, Honda will combine a next-generation V6 engine with extended fuel-efficient range, and highly-efficient drive units, and then apply next-generation energy management control, which optimises the drive modes in accordance with the driving conditions and contributes to the improvement of fuel efficiency.

Aiming to deliver a powerful yet high-quality driving experience befitting the large-size HEV segment, Honda will strive to improve the full-throttle acceleration performance of the finished vehicle by more than 10% compared to the ICE models currently being sold in the same segment by increasing the efficiency of the engine and each drive unit and by utilizing the battery assist.

Overview of dynamics technologies of the Super-ONE Prototype compact EV model

The production model based on the Super-ONE Prototype, which made its world debut at the Japan Mobility Show 2025, is scheduled to go on sale first in Japan in 2026, then in the U.K. and other Asian countries where demand for compact EVs is high (The production model is scheduled to be launched under different names depending on the region: Super-ONE in Japan and the Asia & Oceania region; Honda Super-ONE in some of Asia & Oceania countries; Super-N in the U.K.). With the grand concept defined as 'e: Dash BOOSTER', Honda is aiming to create a compact EV that transforms everyday mobility into an exciting and uplifting experience by offering a variety of features that make the in-vehicle experience more enjoyable for customers.

Super-ONE prototype...

Based on the lightweight platform, which has been continuously advanced for Honda N Series models, the body width was widened by adopting a dedicated chassis with widened tread and fenders. Moreover, heavy components are consolidated and the centre of gravity is lowered by placing the thin battery – the key component of an EV – at the centre of the underbody. In this way, the Super-ONE Prototype realised both one of the lightest bodies among A-segment EVs and a centre of gravity lower than that of conventional gasoline-powered compact cars. With these key features, the Super-ONE Prototype will ensure high responsiveness to driver inputs and maintain stable responsiveness even during cornering, offering outstanding handling performance that responds precisely to the driver's intentions while providing peace of mind.

The production model based on the Super-ONE Prototype will be equipped with 'Boost Mode' developed exclusively for this model. The Boost Mode increases the power output to enable the power unit to fully unleash its performance potential, while also synchronising the simulated 7-speed transmission and the Active Sound Control system to generate powerful engine sound and sharp gearshift feel, as if driving an engine-powered vehicle with a traditional multi-gear transmission.

For the simulated 7-speed transmission, simulated engine speed and gear positions are calculated in real time based on driver inputs such as accelerator operation and driving conditions including vehicle speed and vehicle behaviour during cornering. By optimally controlling driving force and response, the driver can enjoy driving while feeling a sense of oneness with the vehicle. Moreover, the simulated 7-speed transmission also simulates the shock of 'kickdown' during acceleration and vehicle behaviour during the 'fuel cut' – temporarily cutting off fuel injection to protect the engine and properly control the engine rpm. Through these effects, Honda has successfully integrated the driving feel Honda has been pursuing through the years of ICE development into its EVs.

With these playful, new technologies developed exclusively for the Super-ONE, Honda will strive to offer the 'joy of driving' unique only to Super-ONE, which combines the smooth and linear acceleration feel of EVs and the uplifting driving experience of ICE models.

WE ARE LOOKING FOR DISTRIBUTORS

TÜV INDIA ISO 9001-2015 CERTIFIED

Braco

Manufacturers of Cable Glands, Lugs, Terminals & Crimping Tools

Also providing solutions in Non-Ferrous Metals

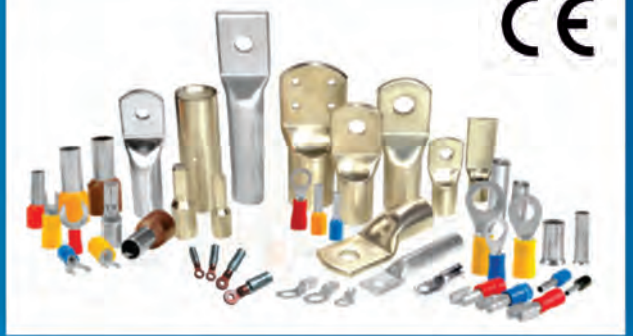
CABLE GLANDS

PESO Certified

CE

CABLE TERMINALS

CE



CRIMPING TOOLS

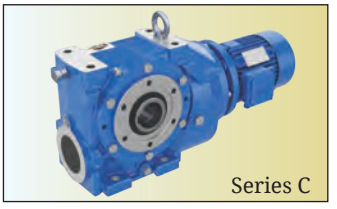
EARTHING RODS & ACCESSORIES

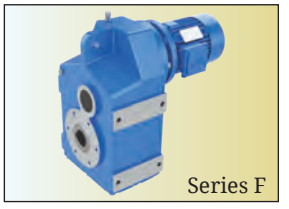
BRACO ELECTRICALS (INDIA) PVT. LTD.

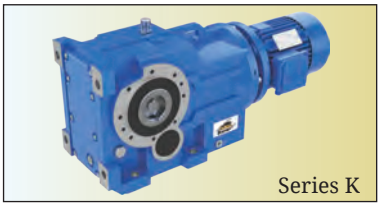
Corporate Office: 10, Ground Floor, Midas, Sahar Plaza Complex, Andheri Kurla Road, Andheri (E), Mumbai - 400 059, INDIA. **T:** +91 - 22 - 4970 4861 | **M:** +91 - 98700 24900 / 93203 14900
E: sales@braco.in / sunil@braco.in | **W:** www.braco.in

Engineering a Complete Power Transmission Ecosystem: Power Build's Full Product Spectrum


Series M


Series C


Series F


Series K

Power Build has engineered one of the most diverse and powerful portfolios in mechanical power transmission. Built on decades of precision engineering, reliability, and innovation, the company's comprehensive range of geared motors, gearboxes, pumps, and drive systems delivers tailored solutions to industries across the globe.

At the core of Power Build's offerings are the four flagship geared motor series:

- **Series M –** Compact Helical Inline Geared Motors delivering up to 160kW and 20,000 Nm torque, ideal for high-efficiency, space-conscious applications.
- **Series C –** Right-angled Heli-Worm Geared Motors, combining quiet operation and high torque up to 10,000 Nm, perfect for constrained environments.
- **Series F –** Parallel Shaft Mounted Geared Motors with integral torque arms, widely used in material handling and steel industries.
- **Series K –** Right-angle Helical Bevel Geared Motors offering up to 50,000 Nm torque, trusted in heavy-duty sectors like cement, power, and mining.

Complementing these are specialized series tailored for unique industrial requirements:

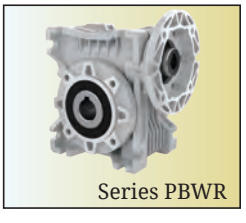
- **Series PBWR –** A universal-mount Worm Gear Reducer crafted from aluminium and cast iron, ideal for compact drive solutions with gear ratios up to 100:1.
- **Series H –** Hoist-duty geared motors supporting lifting capacities up to 12.5 tons, equipped with crane-specific features and brake options.
- **Series PN –** PN Series is a compact yet powerful planetary gearbox solution offering 23 sizes and gear ratios from 3.6:1 to 2250:1. Available in inline and right-angle configurations, it features a wide range of input/output options and mounting styles. Designed for high torque, flexibility, and space efficiency, it's ideal for automation, material handling, and heavy-duty applications. The PN Series reflects PBL's commitment to engineering excellence, durability, and smart power transmission.
- **Series A –** Compact, grease-filled geared motors with a small footprint, perfect for light industrial use and available across India through retail partners.
- **Series J –** Shaft Mounted Speed Reducers featuring the user-friendly KIBO mounting system, favoured in industries like ceramics, paper, and mining.

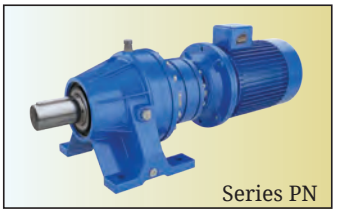
Further enhancing its product ecosystem, Power Build offers:

- **Loose Gears & Pinions –** Manufactured up to DIN Class 6 precision and 1000 mm diameter, supporting customized solutions across sectors like defense, railways, and construction.
- **Roloid Gear Pumps –** Rugged and reliable pumps built for lubrication, cooling, fuel, and viscous fluid transfer in complex industrial setups.
- **PBL VFD Solutions –** Variable Frequency Drives (up to 400 kW) with built-in high-duty ratings, enabling precise speed, torque, and energy control across all motor products.

This cohesive and wide-ranging product suite positions Power Build not merely as a component supplier, but as a complete transmission partner delivering customized, high-performance solutions that keep industries in motion across the globe.

For more information: Email: infopbl@powerbuild.in and Website: www.powerbuild.in


Series PBWR


Series PN


Series A


Series J


Loose Gears & Pinions

ntpl® Since 1975

•Manufacturing •Customisation •Service •Training

One Stop Solution ... for Electrical Testing Needs !

Wide Range of Testing Equipment for -

- Transformer
- Cable
- Switchgear
- Insulators
- ☆ Specialized in High Voltage Equipment

AC High Voltage Test Set

Load No Load Test Bench for Transformer

DFDV Test Set-up

High Voltage Impulse Generator

Series Resonance Type

Load Cycle Test Set-up for Cable

Standerd Type

PC Based Partial Discharge Test Set

NEO TELE-TRONIX PRIVATE LIMITED

Reg. Office : 6/7 Bijoygarh, Kolkata - 700 032
Works : 97(Formerly 117), Mishrapara Road, Rathtala, P.O. -Rajpur, Kolkata - 700 149, West Bengal, India
Phone : +91 9831927749, +91 9830091012, + 91 9748155800 (Open : 10.00AM to 6.00 PM all days except Sundays & Statutory Holidays)
e-mail : ntplindia@gmail.com
Website : www.ntplindia.com

TÜV SÜD ISO 9001 ISO 9001:2015 COMPANY

Thermography That is Smart, Networked and Efficient

testo 883 & testo 872 – Advanced Tools for Predictive Maintenance, Condition Monitoring and Facility Management...

The **testo 883** and **testo 872** thermal imagers are designed to give maintenance, facility management, and industrial professionals a smarter, faster and more reliable way to detect faults before they lead to downtime. With outstanding image quality, intuitive operation and seamless digital connectivity, they help teams work more efficiently, document results with ease and make better decisions in less time.

The testo 883 offers a high infrared resolution of 320 × 240 pixels, which can be enhanced to 640 × 480 pixels using SuperResolution, along with a manual focus that ensures perfect image clarity. The camera's Testo Site Recognition feature automatically recognizes and assigns measuring locations, removing the need for manual image sorting and eliminating mix-ups—an essential advantage when inspecting similar components such as rows of switch cabinets. For precise and comparable thermal images, functions like ε-Assist for automatic emissivity setting and ScaleAssist for optimized thermal scaling further simplify the workflow.

Both the testo 883 and testo 872 integrate smoothly with the testo Thermography App, turning any smartphone or tablet into a second display and remote control, while allowing instant report creation, quick analysis, and easy sharing of results. In addition, both imagers can wirelessly receive measurement data from the testo 605i hygrometer and the testo 770-3 clamp meter, enabling humidity, temperature, current or voltage values to appear directly in the thermal image—particularly useful when assessing electrical loads or evaluating climate-related issues like mould risk.

These imagers are ideal across a wide range of applications: from checking motors, gears, bearings, generators and electrical systems in industrial environments, to identifying defects in solar PV installations, to evaluating insulation, leakage, ventilation and HVAC performance in buildings. Whether it's a factory, a commercial facility, a hospital or an airport, they help ensure safe operation, energy efficiency and long-term reliability.

With their intelligent features, strong connectivity and excellent imaging performance, the testo 883 and testo 872 offer a complete thermography solution that supports predictive maintenance, improves inspection quality, and saves valuable time—making them essential tools for modern maintenance and facility professionals. EI

For more information: Email: info@testo.in,
Website: www.testo.com

Get Energized By

SOLAR ENERGY

The Only Thing That'll Stop Electricity Bill

- Innovative Approach
- Timely Execution
- Faster ROI

Our Services

- Rooftop Solar Power Plants
- Ground Mounted Power Plants
- EPC Services
- O&M Services and Supplies

Greenfinity Solar Xpert Pvt Ltd

235 Progressive Point. Lalpur
Raipur, 492 001 (C.G)

7471116662
7471116663

info.solarxpert@gmail.com
www.solarxpert.co.in

Battery Electric Vehicles

Battery Electric Vehicle (BEV) market is rapidly evolving, however, still it faces several challenges. In any case, BEVs are the next mode of transportation. This article focuses on the components used in BEVs and their functions…

A Battery-operated Electric Vehicle (BEV) is powered entirely by electricity stored in rechargeable batteries, eliminating the need for gasoline or diesel engines. These vehicles use electric motors driven by the battery to propel the car, producing zero tailpipe emissions. BEVs recharge by connecting to external power sources such as home chargers or public charging stations.

They are called next-generation cars because they utilise advanced lithium-ion battery technology to store and deliver electric power efficiently, enabling zero-emission transportation. Without a conventional combustion engine, they operate more quietly and require less maintenance.

The simplified powertrain design, which lacks components like transmissions, clutches, and fuel systems, reduces mechanical complexity and lowers maintenance demands.

However, models without regenerative braking experience slightly lower energy efficiency since they cannot recover energy during deceleration. This makes battery capacity, thermal management, and smart energy distribution critical to maintaining optimal performance and maximising driving range.

Despite lacking regenerative features, these vehicles still offer competitive acceleration, smooth and silent operation, and typical driving ranges between 250 and 400 kilometres per charge, making them a practical and eco-friendly option, especially for urban and medium distance travel.

BEVs powertrain and its components

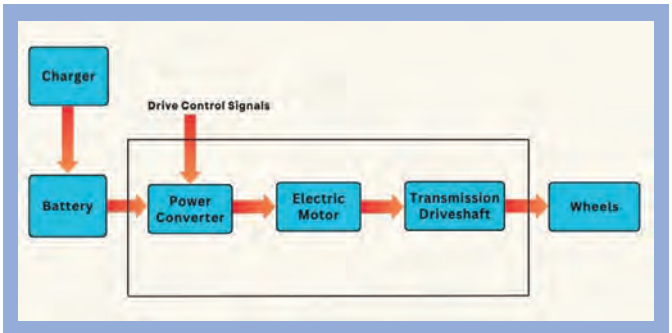


Fig. 1: Powertrain in BEV...

Electric Motors

BEVs are powered by electric traction motors, which convert electrical energy from the battery into mechanical energy to drive the wheels. The most commonly used motor types in BEVs include Permanent Magnet Synchronous Motors (PMSMs), Induction Motors (IMs), and, less frequently, Switched Reluctance Motors (SRMs). Each motor type offers unique performance characteristics suited to various driving and efficiency needs.

Among these, Permanent Magnet Synchronous Motors (PMSMs) are the most prevalent due to their high-power density, superior efficiency, and compact design. PMSMs function through the interaction of a rotating magnetic field, produced by the stator, and the magnetic field of permanent magnets mounted on the rotor. This setup enables the motor to produce high torque at low speeds, making it well-suited for smooth and responsive acceleration in electric vehicles. PMSMs are typically controlled by advanced inverter systems that adjust voltage and frequency using Pulse Width Modulation (PWM), allowing precise control of speed and torque.

In BEVs, the electric motor is usually paired with a reduction gear or direct drive system, depending on the vehicle's drivetrain architecture. This configuration allows the motor to deliver power directly to the wheels, eliminating the need for a conventional transmission. Additionally, modern electric motors are integrated with thermal management systems to prevent overheating and ensure stable performance over a wide range of operating conditions.

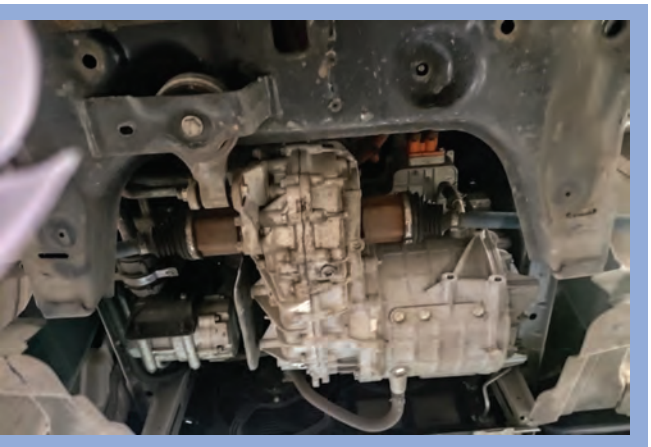


Fig. 2: Permanent Magnet Synchronous Motor for BEV...

Vehicle Control Unit (VCU)

The Vehicle Control Unit (VCU) is a key component in Battery-operated Electric Vehicles (BEVs), serving as the central system that manages and coordinates various vehicle sub-systems. Acting as the vehicle's 'brain', it gathers real-time data from sensors and control units to ensure safe and efficient operation.

In BEVs, the VCU oversees crucial functions such as acceleration, braking, power distribution, thermal management, and communication between systems like the Battery Management System (BMS), Motor Control Unit (MCU), and charging controller. It interprets driver commands such as throttle and brake inputs and sends corresponding instructions to control units. For example, when the accelerator is pressed, the VCU calculates the needed torque and signals the motor controller and inverter to deliver appropriate power from the battery.

The VCU also optimises energy use by managing motor output, limiting power under specific conditions, and controlling regenerative braking where available. Advanced VCUs feature diagnostics and fault detection, allowing the vehicle to identify issues, record errors, and activate safety measures or alerts for the driver.

Fig. 3: Different Control Units in Battery Electric Vehicles...

Modern VCUs use powerful microcontrollers running Real-Time Operating Systems (RTOS) and support communication protocols like CAN (Controller Area Network) or Ethernet for rapid and reliable data exchange across vehicle systems. Electrical sensors are vital in this ecosystem, providing precise data for controlling power, temperature, speed, and safety. As technology advances, improvements in sensor accuracy, miniaturisation, and AI integration will further enhance vehicle performance and safety.

Electrical Sensors in Battery-Operated Electric Vehicles (BEVs)

Electrical sensors are fundamental to the safe and efficient operation of battery-operated electric vehicles. They provide accurate, real-time data that enables intelligent control of power flow, thermal conditions, speed, position, and safety systems. As electric vehicle technology evolves, sensor precision, miniaturisation, and integration with AI-based control systems will play a crucial role in enhancing vehicle performance, safety, and driver experience.

- **Voltage sensors:** They play a critical role in monitoring individual cell and overall battery pack voltage to support safe operation, prevent overcharging or deep discharge, and maintain battery balance. The Battery Management System (BMS) processes this data in real time to enhance battery protection and lifespan. Technologies like resistive voltage dividers safely scale high voltages, Hall Effect sensors provide contactless measurements, and isolation amplifiers ensure safe readings in high-voltage circuits.
- **Current sensors:** They are essential for managing battery charging/discharging, motor control, and auxiliary systems. They enable accurate energy flow monitoring, power optimisation, regenerative braking, and overload protection. Hall Effect sensors offer safe, non-contact current detection, while shunt resistors with differential amplifiers provide precise readings. Advanced sensors like fluxgate and Rogowski coils further enhance measurement accuracy for critical diagnostics and control.
- **Position sensors:** They are vital in motor control, especially in Permanent Magnet Synchronous Motors (PMSMs), and are also used in pedals, gear selectors, and steering systems. Hall Effect sensors detect magnetic field variations for contactless sensing, rotary encoders (optical or magnetic) provide precise angular feedback, and Linear Variable Differential Transformers (LVDTs) measure linear displacement with high precision.
- **Speed sensors:** They monitor the rotation of wheels, motor shafts, and transmission components. They ensure effective torque control, regenerative braking, and overall vehicle stability. Technologies include magnetic reluctance sensors for reliable field-based detection, optical encoders for high-precision speed measurement, and inductive sensors for durable, contactless operation. These sensors are integral to motor efficiency, vehicle control, and safety.

Fig. 4: Various Types of Sensors Used in Battery Electric Vehicles...

Gearbox

In BEVs, the conventional multi-speed gear systems used in internal combustion engine vehicles are generally replaced with simpler configurations. Most BEVs employ

Fig. 5: Gearing Arrangement System for a BEV...

single-speed transmissions or direct drive mechanisms, which significantly reduce drivetrain complexity and enhance overall efficiency.

Actuators

Actuators in these vehicles serve critical functions, such as managing the electric motor's performance and operating various mechanical components, including valve control systems.

Traction inverter

Another essential component is the traction inverter, which plays a key role in the propulsion system. It converts the DC stored in the battery into AC needed by the electric motor. The inverter also fine-tunes the frequency and voltage of the AC output to precisely control the motor's speed and torque, ensuring smooth and efficient operation.

DC-DC converter

To support the vehicle's low-voltage systems, a DC-DC converter steps down the high-voltage DC from the main battery to a lower voltage suitable for operating auxiliary systems like lighting, infotainment, and control modules. Additionally, the onboard charger is responsible for converting alternating current from the power grid into direct current, allowing the battery to recharge safely and efficiently. Together, these integrated components form the backbone of a BEV's powertrain and electrical architecture, enabling reliable performance, safety, and energy efficiency.

Battery and Charging Unit

In BEVs, the battery and the charging unit form the heart of the energy storage and power delivery system. Together, they ensure that the vehicle can operate efficiently, reliably, and sustainably without relying on fossil fuels.

- **Battery system:** The battery in a BEV is a rechargeable energy storage unit, typically based on lithium-ion technology due to its high energy density, lightweight construction, and long-life cycle. The battery pack is made up of multiple interconnected cells, which are grouped into modules, and then assembled into a larger battery pack. This pack is usually installed under the vehicle floor to lower the centre of gravity, improving vehicle stability and handling.

Battery capacity, measured in Kilowatt-Hours (kWh), determines the amount of energy the battery can store and directly influences the vehicle's driving range. Larger batteries offer longer ranges but also increase vehicle weight and cost. The Battery Management System (BMS) plays a vital role in monitoring the battery's health by tracking parameters such as voltage, current, temperature, and State of Charge (SoC). It ensures safe operation by preventing overcharging, deep discharging, and overheating.

Fig. 6: Large Lithium-Ion Battery Pack for BEVs...

To maintain optimal performance, batteries are also supported by thermal management systems, which may use air or liquid cooling to regulate temperature during charging and discharging. Effective thermal control extends battery life and improves efficiency.

- **Battery charging unit:** In BEVs, AC charging is commonly used at homes and workplaces, where alternating current from the grid is converted to direct current by the vehicle's onboard charger before being supplied to the battery. Though slower, it's ideal for overnight or extended charging sessions. For faster energy replenishment, DC fast charging is available at public stations, delivering direct current at high voltage directly to the battery, bypassing the on-board charger and often reaching up to 80% charge in under an hour. Modern charging units also feature smart charging capabilities, such as programmable

Fig. 7: Electric Vehicle Battery Charging Infrastructure...

charging times, real-time energy monitoring, and dynamic power adjustment based on battery status and grid demand.

Functionality of battery-powered electric vehicles

BEVs operate entirely on electrical energy stored in a rechargeable battery pack, typically utili-ing lithium-ion cells due to their high energy density, reliability, and efficiency. The charging process begins when the vehicle is connected to an external power source, such as a home charger or public charging station. AC from the grid is converted to DC by the on-board charger, which then charges the battery. Once charged, the stored energy is managed and distributed by the power electronics controller, a central control unit responsible for regulating the flow of electricity from the battery to the electric motor. This controller interprets signals from the accelerator pedal to adjust motor speed and torque, enabling responsive and energy-efficient driving.

In addition to the primary controller, BEVs may incorporate multiple control mechanisms such as Motor Control Units (MCUs) for precise motor operation, Battery Management Systems (BMS) to monitor battery health and temperature, and Vehicle Control Units (VCUs) that coordinate all electronic systems for optimised performance and safety. The electric motor itself transforms electrical energy into mechanical energy to rotate the wheels, providing instant torque and smooth acceleration. During driving, especially in acceleration and cruising phases, the controller dynamically adjusts the power delivery based on real-time inputs to ensure a seamless and efficient driving experience. These coordinated control systems work together to maintain optimal performance, protect components, and ensure the vehicle operates safely and efficiently under various driving conditions.

Major issues and solutions for battery powered electric vehicles

BEVs face several challenges that hinder their widespread adoption and efficiency. A major concern is their limited driving range, which causes range anxiety despite improvements in battery technology. To combat this, advancements in high-energy-density batteries and smarter energy management are being pursued.

Charging times also remain long with standard AC chargers, but the growing network of DC fast chargers is helping to reduce this inconvenience. High initial costs, mainly due to expensive batteries, are gradually decreasing as production scales and technology advances, supported by government incentives.

Battery degradation over time impacts performance, yet advanced Battery Management Systems (BMSs) help extend battery life by monitoring critical parameters. Limited charging infrastructure, especially in remote and urban areas, is being addressed through increased investments and smart charging technologies.

Battery efficiency also suffers in extreme temperatures, but thermal management systems maintain optimal conditions.

Environmental concerns linked to battery disposal are mitigated through improved recycling and sustainable manufacturing. Overall, while BEVs face technical and infrastructural obstacles, ongoing innovations and supportive policies are steadily enhancing their viability and adoption.

Dr. Bidrohi Bhattacharjee holds a Ph.D. in Electrical Engineering from the Indian Institute of Technology (ISM), Dhanbad, India. He earned his B.E. in Electrical Engineering and M.Tech. in Illumination Technology and Design from Jadavpur University, Kolkata, West Bengal, India. Currently he is working as HoD and Assistant Professor at the Electrical Engineering Department in Budge Budge Institute of Technology, Kolkata, India. His research interests span power electronics, electric drives, renewable energy, sustainable development, electric vehicles, and battery charging technologies. He also holds several patents in the areas of power electronics, renewable energy, and electric vehicles.

Transform Risk.
Unlock Operational Excellence.

Partner with Iyer's Pro-Risk Business Solutions

Digital. Compliant. Reliable.

Services Tailored for Your Success

1 Mn+
Policies & Proposals Processed

3 Mn+
Data Points Verified

₹ 1 Bn+
Amount Saved For Clients

SERVING 50%+
Life Insurers in India & Beyond

FOR INSURERS, NBFCs, AND **OTHER ORGANISATIONS**

OPERATIONS SUPPORT SERVICES:
End-to-end process management in insurance, lending, and compliance.

RISK MANAGEMENT SUPPORT:
Expert assistance for underwriting, claims, fraud control, and regulatory adherence.

INDIA STACK API-DRIVEN SOLUTIONS:
Future-ready, secure integrations for KYC, digital onboarding, recruitment checks and financial data access.

EMPOWERING **MSMEs TO THRIVE**

INVENTORY MANAGEMENT:
Customized, efficient systems successfully implemented for leading MSME manufacturers.

PAYROLL & ACCOUNTING:
Simple, reliable solutions for small businesses. Get compliant and stay in control.

IT ENABLEMENT:
Website/app development, business automation, and low code/no code solutions for growing enterprises at affordable costs.

Experience the Pro-Risk Advantage

- ✓ Reliable back-office & compliance support services
- ✓ Tech-led, compliance-first processes
- ✓ Tailored for businesses of every size

Why Choose Iyer's PROrisk BUSINESS SOLUTIONS **Your Trusted Partner in Digital Operations & Risk Excellence**

EXPERTS-LED
Chartered Accountants, Tech Specialists & Industry leaders

PROVEN IMPACT
Results delivered across top insurers & other organisations

THOUGHT LEADERSHIP
From the author of 'Creating Digital Excellence' – a CXO favorite book

CLIENTS SPEAK
1) Pro-Risk helped us digitize & scale effortlessly
2) True partners
3) Solved our complex problems.

Let's Discuss Your Needs

hello@prorisk.in www.iprorisk.com

ISRAELI Battery Refurbishment Leadership in India since 2017

VOLTAREDOX, an affiliate of Battery Solutions International BSI Israel, represents a global force in battery life extension and refurbishment. BSI operates in more than twenty countries and is recognized as a pioneer in clean technology for extending the life of lead acid, nickel cadmium and lithium ion batteries through its patented additive technology and advanced refurbishment processes.

This end to end solution significantly reduces battery maintenance costs for telecom operators and traction battery users while ensuring a completely green, zero waste approach. Since 2010, BSI has demonstrated consistent success through its global network of restoration facilities.

Innovation that Sets the Company Apart

The core strength of BSI lies in its Israeli clean technology innovations that focus on eco-friendly battery refurbishment. Its patented organic additives and capsules address one of the most common battery issues, sulphation, allowing refurbished batteries to achieve double their original life. This process offers a powerful combination of economic savings and environmental sustainability while reducing hazardous battery waste.

Global Expansion

BSI's footprint spans over twenty countries through Exclusive License Franchisee. In Asia, operations are already established in India at three locations along with Vietnam, the Philippines and Myanmar. VOLTAREDOX is expanding rapidly within India. Production facilities are now active in NCR Delhi with upcoming launches planned for the southern region. VOLTAREDOX is offering Franchisee opportunity on Pan India basis at micro & full scall business model. BSI Israel's broader refurbishment division is also preparing new sites in Pune and Hyderabad, further enhancing the company's national network.

Market Shifts after the Pandemic

The post pandemic environment has pushed industries to prioritize cost efficiency. As VOLTAREDOX offers refurbishment at one third the cost of new batteries with twice the lifespan, customer demand has surged by nearly three hundred percent. This shift has strengthened the organization's position across industrial and commercial sectors.

An Economic Business Model

VOLTAREDOX champions a circular economy model through both environmental impact and entrepreneurial empowerment. The company is introducing micro franchise opportunities for rural and urban communities, enabling new entrepreneurs to enter the growing sustainable energy market.

Specialised Expertise

VOLTAREDOX is the only organization in India capable of performing comprehensive restoration comparable to bypass surgery for individual cells of traction batteries used in electric forklifts and stackers. The process extends battery life at just a quarter of the cost of replacement and includes a two year warranty. This capability has strengthened the company's presence in regions including NCR Delhi, Haryana, Punjab, Himachal Pradesh, Chennai, Mumbai and Pune.

Sustainabilty

For more than seven years, the collaboration between VOLTAREDOX and BSI Israel has fueled major advancements in battery life extension, contributing to global missions of achieving net zero emissions and reducing hazardous waste. With proven technology, a strong market presence and growing opportunities for entrepreneurs, VOLTAREDOX is shaping a future where sustainable battery solutions are accessible, economical and environmentally responsible.

Future plans

BSI is in the final phase of research and development for commercial scale lithium ion battery refurbishment for electric vehicles that include Toyota Prius, Tesla and BYD buses. Azerbijan, Uzbekistan, China, Malaysia have recently adopted BSI Israel's Batteries Refurbishment Technology. Looking ahead to 2026, the company envisions large scale operations dedicated to both lead acid and lithium ion batteries to reduce the global burden of hazardous battery waste. EI

Harinder Mohan Singh
Founder and Director of Voltaredox (Effulgent BR Resources).

BATTERY REFURBISHMENT : Now Part of
New Battery Waste Mgmt Rules 2020
BSI - ISRAEL Pioneer in Battery Refurbishment &
BIG COST SAVING on BATTERY LIFE LONGEVITY

NEXT EVBATTERY REFURBISHMENT AFTER LA & NI-CD BATTERIES

Refurbishment is now New Normal to RECYCLING

AN AFFILIATE OF BSI - ISRAEL

NCR Delhi, Pune, Haryana, Punjab & next is Hyderabad

60-80% COST SAVING on BATTERY LIFE LONGEVITY

FRANCHISEE CUM ENTREPRENEUR OFFER

OLD BATTERIES REFURBISHMENT BEFORE RECYCLING (Micro franchises@4.5 lakhs)

Major Clients From :

• Telecom • Pharmaceuticals • Automobile • Banking • Solar,
• Medical Equipment • Railways • Turbines

1ST TIME IN INDIA: 3RD LIFE TO UPS BATTERIES

EFFULGENT BR RESOURCES LLP

8860868600 / 9810635349
support@voltaredox.com / vcare@voltaredox.com
www.voltaredox.com

VOLTAREDOX
Pioneer in Battery Refurbishment

ReBeLMove Pro: Modular Robot Platform for Logistics, Assembly and Handling

Autonomous mobile robot from igus promises simple configuration with flexible superstructures and easy commissioning...

Pressure in terms of costs and efficiency demands a lot from modern production. With the ReBeLMove Pro, igus is launching a modular Autonomous Mobile Robot (AMR) that is easy to customise according to the modular principle - from small load carrier transport to robot solutions. It can be integrated into company processes without any previous experience. The ReBeLMove Pro is available from just €39,800, which makes it around 25% more cost-effective than most competitor models.

The ReBeLMove Pro is based on a compact, rectangular transport robot on four wheels with an electric drive. The AMR is 795mm long, 560mm wide, 195mm high, weighs 60kg and is painted in black with orange accents typical of igus. The robot can navigate autonomously at a speed of up to 2m/s, carry up to 250kg or pull up to 900kg in material handling. One battery charge is enough for a full working day of eight hours. By adding attachments to the ReBeLMove Pro, users can adapt it to different tasks in material handling. Examples include height-adjustable conveyor belts and an articulated arm cobot for assembly workstations, a trailer for transporting materials or a shelf with light signals for more productive order picking. The new robot can also be used outdoors. "igus itself is already using the ReBeLMove Pro as a shuttle to transport products away from injection-moulding machines in production," says Sebastian Thorwarth-Kienbaum, Expert for Low Cost Automation at igus. "These are tedious, routine tasks in material handling that companies find difficult to get people excited about." Within just two months, for example, a fully automated container transport system including interface integration was realised in igus's production, from conception to implementation. It transports ball bearing components from the injection-moulding machine to the fully automatic assembly machine without human intervention.

Return on investment after just 12 months

However, companies not only save costs when purchasing the AMR, but also during commissioning and operation.

"System integrators and software licences often cause high follow-up costs, which lead to companies putting the topic of automation on ice again in frustration," says Thorwarth-Kienbaum. "We have therefore made a point of ensuring that the ReBeLMove Pro can be integrated and operated without outside help or automation experience." During a simple round trip, the robot automatically creates a 3D digital map of the room. It uses LIDAR sensors, 3D sensors and a RealSense camera and can map a 200-square-metre room in just under three minutes. The robot can then move autonomously without the need for complex guidelines or tracks on the floor. Programming is also quick and intuitive: users can create movements with software in just 15 minutes and without any programming knowledge. Integration into existing IT landscapes with open interfaces such as IoT, VDA 5050, REST, SAP or ERP is just as straightforward. The ReBeLMove Pro is also compatible with external fleet management solutions such as Fleetexecuter, Kinexon or Naise. "Thanks to the low investment costs and uncomplicated commissioning and operation, the average return on investment for a ReBeLMove Pro is twelve months. The ReBeLMove Pro costs only €38,900, i.e. around 25% less than standard market solutions, which generally start at €50,000 - without compromising on functionality," summarises Thorwarth-Kienbaum. EI

More information: Email: aheinzelmann@igus.net or Website: www.igus.in

Advanced Partial Discharge Filtering Technology for a Smarter HV Lab

In high-voltage laboratories, achieving accurate, repeatable, and IEC-compliant Partial Discharge (PD) measurements is becoming increasingly challenging.

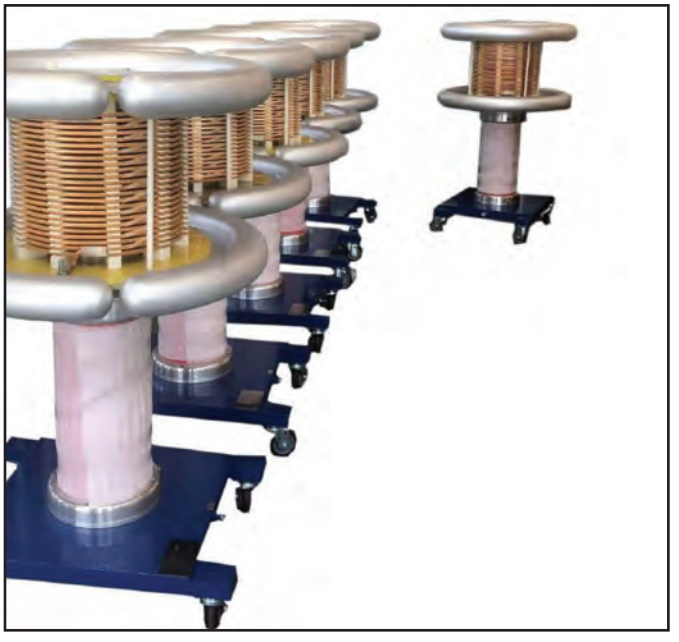
Modern test environments are exposed to significant RFI/EMI, switching spikes, harmonics, and ground noise, all of which overlap the IEC 60270 PD detection band (40–300 kHz).

These disturbances can mask true PD activity, lead to false readings, and compromise the credibility of insulation diagnostics.

To address this challenge, **MTEKPRO Technologies Pvt. Ltd.** has introduced the BHT Partial Discharge Filter — a high-performance noise-suppression system engineered for HV laboratories, transformer manufacturers, cable test facilities, and advanced PD diagnostic setups. The BHT PD Filter is engineered to remove these disturbances at the source—ensuring clean, stable, and IEC-compliant PD measurements.

Why PD Filters are Critical in HV Testing

Partial Discharge signals exist in the picocoulomb range, making them highly vulnerable to noise such as communication transmitters, switching equipment, VFDs, UPS systems, harmonics, and ground loops. Without proper filtering, noise contaminates the measurement, masking true PD events.



Engineering Architecture of the BHT PD Filter

- **Series Inductors (L) –** Block high-frequency interference
- **Shunt Capacitors (C) –** Divert noise to ground
- **Electromagnetic Isolation** – Break coupling paths
- **Frequency** – Selective Attenuation Networks.

Available Topologies — T-Filter & π-Filter

- Single – Phase T-Filter

Ideal for transformer, cable, and GIS offline PD testing. Provides strong attenuation of high-frequency disturbances.

- Three-Phase π-Filter

Balanced three-phase noise suppression for switchgear, motors, and MV systems.

Applications

- Transformer PD tests
- HV cable PD tests
- GIS offline PD testing
- Bushing, PT/CT, reactor insulation tests
- Motors & generator insulation diagnostics
- OEM and FAT HV laboratories

As high-voltage systems evolve, maintaining clean, noise-free PD measurements is essential for reliable insulation diagnostics. The BHT PD Filter delivers stable, IEC-compliant test conditions, giving HV laboratories and manufacturers the confidence to make accurate, data-driven decisions.

For more information:
Email: info@mtekpro.com, Website: www.mtekpro.com

0BB Technology: The Next Evolution in Advanced PV Modules

Zero-Busbar (0BB) module technology is rapidly emerging as a key advancement in the photovoltaic industry as manufacturers push for higher efficiency, lower material usage, and improved module reliability. Traditional solar cells have long depended on multiple busbars to collect current, but these wide metallic strips introduce shading losses, increase silver consumption, and contribute to solder-related stress on the wafers. By eliminating these busbars entirely, 0BB technology unlocks more active surface area, streamlines current flow, and supports more mechanically stable module architectures.

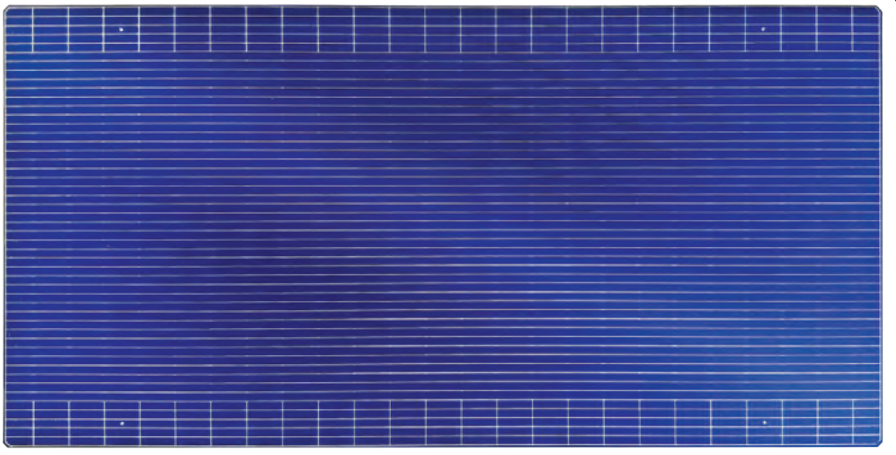


Figure: 0BB Solar Cell...

In a 0BB design, current is collected directly through ultra-fine metallization fingers on the cell surface. These fingers are linked to the module's interconnection system using conductive adhesives, structured ribbons, or wire-based micro-ribbons. This busbar-less architecture not only enhances light absorption but also lowers series resistance due to shorter current paths. As a result, modules typically exhibit higher fill factor, improved power output, and more uniform performance across production batches. Removing busbars also leads to notable silver paste savings—which contributes directly to lowering the overall cost per watt.

From a mechanical perspective, 0BB technology is well suited for the industry-wide trend toward thinner silicon wafers. Instead of relying on soldered joints, which can cause stress, bowing, or crack propagation, 0BB modules often use low-temperature conductive adhesives that distribute mechanical load more evenly. This results in better long-term reliability, reduced micro-crack development, and enhanced module durability during thermal cycling, damp heat exposure, and mechanical load testing. The distributed nature of the current collection also reduces the likelihood of hotspot formation, contributing to more stable field performance.

Despite its advantages, 0BB technology does come with challenges. Ultra-fine fingers are more sensitive to breakage, and many existing stringing machines are not compatible with busbar-less interconnection without modification or replacement. Although silver usage decreases, the cost of conductive adhesives or advanced ribbons can partially offset savings, requiring careful bill-of-material (BOM) optimization. Even with these challenges, industry momentum is building quickly. Top global manufacturers are already integrating 0BB or hybrid busbar-less architectures into their TOPCon, HJT, and next-generation tandem modules, recognizing the significant efficiency and reliability benefits.

In a nutshell, Zero-Busbar technology represents a clear and meaningful step toward next-generation photovoltaic modules. By removing busbars and adopting advanced interconnection strategies, module makers can deliver superior electrical performance, improved mechanical resilience, and reduced material usage—all essential factors as the industry moves toward multi-terawatt global deployment. With its compatibility across modern and future cell technologies, 0BB stands out as a forward-looking solution that aligns with the sector's long-term goals for sustainability, efficiency, and scalability.

Source: R&D Dept. WAAREE Energies Ltd.

BALAJI SWITCHGEARS™

Redefining Electrical Distribution Since 1990

TRANSFORM YOUR BUSINESS WITH PRODUCTS AND SOLUTIONS DESIGNED BY EXPERTS

OUR BUSINESS SEGMENTS

- Product Distribution
- Automation Solutions and Programming & Commissioning
- AMC & Retrofitting
- Panel Building

- Distributor & System Integrator of Industrial Automation & Switchgear Products.
- Globally Renowned Brands.
- Strong Sales/Technical/Accounts/Logistics Support.
- Over 10,000 Satisfied Clients Across the Globe.
- Over 40,000 Business Transactions Every Year.

PRODUCT OFFERING

- LV Switchgears & Control Gears
- Controlling & Signalling
- Industrial Plug & Sockets
- Enclosure Systems
- Meters & Capacitors
- Automation & Sensors
- Wires, Cables & Accessories
- PLC/VFD Panels
- DOL & Star-Delta Starters
- Distribution Boards & Junction Boxes
- MCC & PCC

AUTHORISED CHANNEL PARTNERS

Schneider Electric | OMRON | LAPP | Telemecanique Sensors | nVent HOFFMAN | connectwell Terminal Block & Accessories | GYANOMATION SYSTEMS | TRINITY TOUCH | ELMEASURE | KEI Wires & Cables

www.balajiswitchgears.com | mktgindia@balajiswitchgears.com
Head / Regd. Office: 2006, Katra Lachhu Singh, Bhagirath Palace, Delhi-110006, Contact: +011-2386 0986, 2387 4519, 2387 3969, 4110 0313, 4110 0314
Marketing / Branch Office: Plot No. 70A-13, Rama Road, Najafgarh Road, New Delhi-110015, Contact: +011-4709 3969, 4475 5186/187/188

ADDRESSING THE TRIPLE PLANETARY CRISIS

Solar bicycles offer environmental benefits like zero emissions and reduced reliance on fossil fuels, as well as economic advantages such as lower running costs and reduced electricity bills. They also provide practical benefits like increased range, mobility for charging in remote areas, and health benefits from both pedalling and electric assistance...

The United Nations (UN) has adopted a term and framework called the 'Triple Planetary Crisis', to refer to the three main interlinked issues that humanity currently faces:

- **Climate change:** The long-term shifts in temperatures and weather patterns, largely driven by human activities.
- **Biodiversity loss:** The decline in the variety of life on Earth, including the extinction of plant and animal species and the degradation of ecosystems.
- **Pollution:** The contamination of air, water, and soil from various sources, including plastic waste, chemicals from extractive industries, and air pollutants.

Why is it significant?

The term - 'Triple Planetary Crisis' - underscores the interdependence of these issues and their collective impact on the planet's ecosystems, societies, and economies. It highlights that

these crises are not separate problems but are linked, deeply intertwined and intensify each other, threatening human health, well-being, and prosperity. Hence, they must be addressed together. Each of these issues has its own causes and effects and each issue needs to be resolved if we are to have a viable future on this planet.

Unsustainable production and consumption patterns are a common underlying driver for all three issues. In the words of UN Secretary-General António Guterres, "Humanity is waging war on nature. This is senseless and suicidal."

What is being done to tackle it?

There are UN agencies dedicated to each of the planetary crises: The UN Framework Convention on Climate Change (UNFCCC) tackles climate change; UN Environment tackles pollution and UN Biodiversity focuses on biodiversity.

The Paris Agreement

Exactly 10 years ago, the world signalled that climate change is a serious threat to life on the planet, and with the historic 2015 Paris Agreement, put into place the current international mechanism for combating the crisis. The foundation of the Paris Accords was the agreement that atmospheric heating had to be kept below 2 degrees Celsius (above pre-industrial levels) by 2100, and that nations would strive to further limit this to below 1.5 degrees Celsius. The latter is the true heating barrier, beyond which life on the planet will face all kinds of nightmare scenarios.

The COP30 climate conference

The COP30 international climate conference that is ongoing in Belem, Brazil, on the outskirts of the Amazon rainforest, has a lot on its plate since the world has missed the 1.5 degree target. The last two (successive) years (2024, 2025) have seen annual global temperatures being 1.5 and 1.6 degrees Celsius hotter. Although it is possible to first overshoot and then reduce heating to under 1.5 degrees Celsius, scientists are clear that we will overshoot the 1.5 degree barrier far sooner than anticipated, with the average global temperature 1.4 degrees hotter right now and consequences are already being felt.

The consequences range from deaths due to weather-related disasters (of which there has been a five-fold increase in the past 50 years) to the 21.5 million people displaced by climate-change related disasters every year. Coral reefs are nearly dead, catastrophic cyclonic storms are hitting all around the world, and Antarctic glaciers are melting at a shocking rate.

The more extreme and more frequent floods, droughts and storms not only means a huge human cost, but a huge environmental and financial cost as well. A 2021 report from Swiss Re, one of the largest providers of insurance to other insurance companies, revealed that climate change could cut the value of the world economy by $23 trillion by 2050 – with developed nations such as the US, Canada and France losing between six and ten per cent of their potential economic output. For developing nations, the effects of climate change are even more dire, with Malaysia and Thailand, for example, both seeing their economic growth 20 per cent below what would otherwise be expected by 2050.

A group of scientists for the thinktank Climate Analytics published a report earlier this month outlining a possible 'Highest Possible Ambition' pathway by which global heating can be limited to a peak of 1.7 degrees Celsius of warming by 2050 and then brought down to about 1.2 degrees of warming by 2100. Broadly speaking, the report states that this can be achieved by focusing on four goals:

- Renewable energy powering 66.67% of global electricity needs by 2050.
- A fossil fuel-free global economy by 2070, with coal phased out in the 2040s, gas in the 2050s and oil in the 2060s.
- Finding a way to rapidly scale up carbon dioxide removal (CDR) technologies on a commercial scale by 2050.
- An urgent focus on cutting methane emissions.
- What can I do about it?

There are many things you can do on an individual basis: consume less; walk or cycle instead of driving; recycle; use less water, and perhaps most importantly contact your elected representatives. Ask them what they are doing to combat the triple planetary crisis – tell them it is important to you and your peers.

Driving a private car is habit forming. Like many others, you may have already become addicted to cars. Try to break free! To make the transition to bicycles effortless and smooth, solar bicycles can work as a great enabler. It works on the principle of energy harvesting, which is explored here.

Table 1: Harvesting vs. Generation		
	Energy Harvesting	**Energy Generation**
Approach	A complementary approach to energy generation, offering a way to power small devices locally and sustainably	Provides the bulk of our power needs
Sources	Utilises ambient sources that are often overlooked	Relies on more traditional and sometimes finite resources or large-scale renewable sources
Cost and Maintenance	Can be a low-cost and low-maintenance solution for powering specific devices	Energy generation can involve significant upfront and ongoing costs.
Focus	Capturing and utilising ambient energy sources to power small, low-power devices	Producing large amounts of electrical power for widespread use
Scale	Deals with small amounts of power for localised use; Micro to milliwatt range	Focuses on large-scale power production; kilowatt to gigawatt range
Examples	Solar cells powering sensors, piezoelectric materials converting vibrations into electricity, thermoelectric generators using temperature differences.	Fossil fuel power plants, nuclear power plants, hydroelectric dams, large-scale solar and wind farms.
Applications	Wireless sensors, wearable electronics, remote monitoring systems, IoT devices.	Powering homes, businesses, industries, and transportation systems.

What is energy harvesting?

Energy harvesting is the process of capturing and converting energy from the environment into electrical power. It is one of the key emerging technologies of the 21st century. It is defined as the collection of local naturally available energy for local use. It refers to the collection of energy from the environment; energy that would otherwise be lost to heat.

An energy harvesting source could be Radiofrequency, Thermoelectric, Piezoelectric, Electromagnetic, Photovoltaic (PV) or Chemical energy; thus, may be different from renewable energy sources.

Can all Photovoltaic sources be categorised as 'energy harvesting'?

No. For a PV source to be considered as a 'Energy harvesting' source, it should meet both the following criteria:

- It should be a local naturally available energy source
- The collection should be for local use.

Not all PV sources do so.

Examples of PV projects not categorised as energy harvesting

- Mega PV projects generate power for transmission through an electrical grid – not for local use; hence, do not fall under energy harvesting.
- Roof-top Solar projects also use Grid-tie inverters for export of unused energy, hence, not strictly for local use; again not under energy harvesting.

Example of a PV source that is truly an energy harvesting source

An example of a PV project that is truly an 'Energy Harvesting' source is a 'Solar Bicycle'. A solar bicycle carries its own, dedicated solar panel (PV source) on its frame, hence it is a local and naturally available energy source - meeting the first criteria. The energy collected from the solar panel is used primarily to drive the BLDC motor to propel the bicycle. The energy is also used for the headlights, tail-light, horn and other electrical circuits. Both energy uses are local to the bicycle, meeting the second criteria. Hence, a solar bicycle can be categorized, truly, under 'Energy Harvesting' category.

Harvested solar energy vs. metabolic energy

- Solar Bicycles - most efficient transport in its price range!
- 4 times more efficient than even human beings!

Table 2: Energy Consumed by Different Vehicles				
Vehicle	**Mode of Operation**	**Human (Wh/km)**	**Electric / Solar (Wh/km)**	**Total = (Human + Solar) (Wh/km)**
Bicycle	Manual	27.89*	0	27.89
Solar Bicycle	Solar Assist	13.95*	3.35	17.29
	Throttle/ Cruise Mode	0	6.69	6.69
Electric Scooter	Throttle	0	35	35
Electric Car	Throttle	0	120	120
*kcal converted to Wh using equation: 1 kcal = 1.1622 Wh				

Table 3. Harvesting vs. Charging	
Energy Harvesting	**Electric Charging**
Generally, regardless of whether Radiofrequency, Thermoelectric, Piezoelectric, Electromagnetic, Photovoltaic or Chemical; it is a free and ubiquitous source. Overcomes main drawback of electric charging - no need to hunt for charging locations! Particularly useful in rural countryside having little or no access to electricity.	The first big disadvantage of electric charging is: the need to hunt for nearby charging locations; even near one's own office or home apartment!
Energy harvesting is usually a continuous process. Hence you are always on the go! No need to waste precious time for charging.	The second big disadvantage of Electric Charging is: waste of precious time while the battery is kept on charge. You are incapacitated till the charging process is completed.
The system gets automatically charged through energy harvesting; need not be paid attention; need not be attended to. Energy harvesting process does not need an external charger to be plugged in.	The owner needs to plan the charging time and location. Needs to pay attention to the charging process and needs to attend to the charger plug in and plug out process and sequence.
Designed for applications having needs for small amounts of energy on a regular or daily basis. Ideal for Daily (7x24) use products.	Designed for applications with large energy needs occasionally; not on a daily or continuous basis. Ideal for occasional use products. Most of the time the product would stay unused for long durations

- To travel a distance of 1 kilometre, 24 kcal (27.89 Wh) of human (metabolic) energy expended
- To travel the same distance (1 kilometre), only 6.69 Wh of harvested solar energy is required.
- Solar assisted pedaling mode gives a good combination of say 12 kcal (metabolic) + 3.35 Wh (solar) consumption for health and environment.

WIPO and climate change

The World Intellectual Property (IP) Organization (WIPO) is the United Nations agency that serves the world's innovators and creators, ensuring that their ideas travel safely to the market and improve lives everywhere. WIPO's IP data and information guide, impact-driven projects and technical assistance ensure IP benefits everyone, everywhere. It has put innovation, technology, and IP at the forefront of the fight against climate change.

In October 2025, WIPO released its Green Technology Book that focuses on energy technology solutions to address climate change in the fastest-growing region of the world - the Asia-Pacific. With its scale, rapid growth, and high energy intensity, Asia plays a key role in the global energy transition. The book highlights real solutions shaping a sustainable future across Asia.

It would be interesting to note that BEM® Savitré™ solar bicycle is one of the 200 examples that has appeared in the WIPO's Green Technology Book. Thus, the importance of energy harvesting in the fight against climate change has been recognised by WIPO. It is, now, for the policymakers, businesses, innovators, and solution seekers with a forward-looking perspective to act and use the energy harvesting technology to drive the transition toward sustainability.

Dr. Vithal Kamat has a Doctorate in Artificial Intelligence from the University of New Brunswick, Canada as a Commonwealth Scholar in 1996. He completed Masters in Control and Instrumentation from IIT Bombay. He has worked essentially in the Telecom Industry in the 1980s, the Power Industry in the 1990s, Embedded Industry in 2000s, Engineering Education in 2010s, AIoT in the 2020s and is currently in solar mobility. His contributions have been in developing indigenous electronic switching systems under Sam Pitroda's CDOT, restructuring India's Power Sector under the Ministry of Power, developing Embedded Systems with NXP Semiconductors, Women's Professional education (as Principal of Engineering Institute- MBICT) and introducing disruptive technologies such as kVAh metering, and solar e-bicycles, for the 1st time worldwide.

CPX 200 - Unleash the Expert!

CPX 200 is our new solution for current and future industry challenges: This next-generation multifunctional test set comprises the CPX 200's hardware elements, the HVX10 system component, the CPXpert PC software and the CORTEX Grid data assessment platform. We've combined them all into a harmonized Ecosystem that's lighter, smarter, and more powerful than anything else in the industry. One compact system covers power transformers, instrument transformers, and switchgear testing, replacing entire truckloads of equipment with a solution that weighs under 30 kg (66 lbs). Its modular hardware lets you scale from high current to high voltage in seconds. The integrated and intuitive CPXpert software harmonizes seamlessly with the new cloud-based CORTEX Grid data assessment platform, ensuring guided workflows, one-click reporting, and unified data across the entire fleet. The result is faster setups, safer testing, and actionable insights that help service providers and utilities save time, reduce risks, and make better decisions.

Three questions to the Product Manager, Michael Rädler:

Michael, as Product Manager, you were involved in the project from the moment it began. What impressed you most during that period?

Michael: "What I found most impressive throughout the entire project was the team's unbelievable combination of innovative spirit, trust, and cohesion. We could feel right from the very beginning: With the CPX 200, we wanted to do more than just develop another device; we wanted to set new standards. For me personally, the fact that OMICRON not only went down this path with us, but actively supported us, providing us with a solid foundation of confidence. I found the interdisciplinary cooperation that took place particularly inspiring. Different experts from all areas came together to work on a shared vision. Each one of them applied their expertise with exceptional attention to detail, without losing sight of the bigger picture. But what made the project particularly unique for me was the consistency of customer focus. We didn't hide our development behind closed doors. Users remained closely involved, we absorbed and scrutinized their feedback, and often, we even completely rethought

our approach. This ongoing dialogue made us better, strengthening the team's cohesion. In the end, we all knew what we were doing this for: for our customers and a product we could take pride in."

On a scale from one to ten, what level of engineering is involved in the CPX 200, and why?

"If I had to rate the CPX 200's engineering level on a scale from one to ten, I wouldn't hesitate to give it a nine. I'm aware that, being someone who was involved in this project from the moment it began, I have a certain amount of bias. However, this isn't my way of congratulating myself. I'm looking at its actual value and technical implementation from an objective perspective, and I believe it's truly exceptional.

We didn't get bogged down in simply creating technology for its own sake; instead, we consistently worked towards solutions that would generate sustainable added value for our customers.

Implementing requirements, whether in the field of safety, weight, multifunctionality, or performance, demands the highest level of engineering skill, and that's exactly what it received. Personally, I lean towards simplicity, as I'm fascinated by achieving as much as possible with as little as possible. But when it comes to technology, simplicity isn't a trivial matter. It denotes a reduction of the essentials, which reduces the error rate, increases robustness, and allows systems to be controlled and operated over a long period of time. The CPX 200 remains a highly complex system. However, we significantly expanded our technical and conceptual toolbox precisely to manage its complexity with precision, with a clear focus on ease of use and understanding the system."

Now as CPX 200 has entered the market you probably already have several ideas for further development. Is there a specific challenge you'd like to tackle?

Michael: "As Product Manager, I'm constantly working on ways to continue the CPX 200's development. Naturally, there are already plenty of ideas surrounding the direction that journey could take. What's particularly exciting is that the CPX 200 is a platform designed with a forward-facing approach that applies to its hardware and software. Its modular architecture opens fantastic possibilities for seamlessly integrating new applications, test methods, and features into an existing ecosystem. Targeting and exploiting this potential will be a significant challenge in years to come, not simply from a technical perspective, but also in making sure we remain focused on our customers' actual needs.

We have a clear vision, and concrete initiatives are already on the radar, but for me, one thing is essential: active listening. Only by holding continuous discussions with our customers and partners and taking their challenges and ideas seriously can we develop solutions with pioneering technology that are also genuinely practical. As a Product Manager, this represents both my highest responsibility and the challenge I'm most attracted to."

Innovation Redefined: Discover What Makes the CPX 200 Exceptional

Your safety. Our Standard.

From standard to benchmark - CPX redefines safety

CPX 200 was developed with safety in mind. Our comprehensive safety features reduce the risk of electrical hazards significantly. Every device is equipped with an extensive set of certified hardware safety features like red and green signal lights, the emergency switching-off button, the INTERLOCK key and an optional acoustic signal. With a workflow according to EN 50191, wiring guidance with indicator lights and the optional external warning lamp* we minimize errors and potential hazards onsite.

*coming soon

Maximum power per Space

Unmatched Performance – Unbeatable Portability

At just 10.6 kg (23.3 lb), the CPX 200 is the lightest multifunctional testing device in the market. It handles testing of power transformers, instrument transformers and switchgears in medium and high voltage areas. Fully equipped with the High Current Model and the system component HVX10, the total system weight stays under 30 kg (66 lb). New backpack-style carry bags ensure easy access in confined areas, while the robust yellow transport case doubles as a trolley and substation work tray for safe, convenient and ergonomic use.

Future-proof Performance

Experience the next Next-Gen Solutions

CPX 200 is designed to meet the demands of today and the challenges of tomorrows energy systems. Compact, powerful, and exceptionally safe, it sets a new benchmark for next-generation multifunctional testing. Developed according to internationally recognized standards, the CPX 200 meets all current safety and cybersecurity requirements. Ideal for substation commissioning and diagnostic testing of medium- and high-voltage assets, it delivers outstanding performance across hardware, software, and accessories, ensuring long-term reliability and maximum value.

Modular Intelligence

Unleash the Power with Modular Intelligence

The CPX 200 can be precisely configured to your needs, thanks to its modular hardware, software, accessories and tailored service offerings. You can begin with a flexible, multifunctional testing solution and later easily expand into a specialized testing system for your specific application needs.

Unlock the full potential with:

- > 1000A AC/DC with High Current Module
- > 10kV AC/DC with the system component HVX10
- > Testing frequency range: 1 - 600Hz and DC
- > and much more…

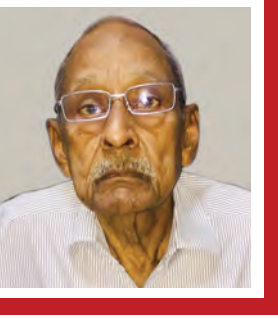
Easy to operate

Easy – Intuitive – Reliable

The system streamlines testing with combined measurement channels, reducing wiring efforts. It delivers accurate true three-phase voltage and ratio measurements and features a coloured multi-touch display with automatic brightness adjustment. Guided workflows with nameplate support ensure efficient, error-free operation. A unified interface enables multi-asset testing, with complete, automated documentation and seamless test planning through to final reporting.

OMICRON Energy Solutions Private Limited
Email: info.india@omicronenergy.com
Website: www.omicronenergy.com

Managing the Menace of Voltage Variations



B. B. Jindal
Founder, Jindal Electric & Machinery Corp.

Voltage variation is a very common phenomenon. In India, all electrical equipment is designed for 230/400 volts single/three-phase. The input voltage is generally low during day time and high during night hours. Voltage variation is everywhere, at some places it is high/low or sometimes even both (fluctuating).

Effects of high or low voltage

Automatic Voltage Controller

At the high Voltage condition, current of electrical/electronic equipment increases accordingly. This high current increases the losses of equipment resulting overheating the insulation of electrical/electronic equipment and becomes the cause of pre-mature failure of electrical/electronic equipments. It also increases the power consumption & MDI etc.

At low voltage condition, the electrical/electronic equipment does not work/operate properly. Repeated tripping of the system ultimately leads to wastage of time/ loss of production.

Automatic Voltage Controller (AVC)

To solve the challenge of voltage variation, Automatic Voltage Controller (AVC) is required. The main part of AVC is the Voltage Regulator.

There are two technologies of Voltage Regulator available in the world:

- **Dimmer Type** Torroidal wound with copper wire and sliding contact carbon brush assembly un-suitable for continuous load with higher losses up to 8% at rated current.
- **Linear Type** Vertical Wound with cooper strip and have compensating winding Carbon Rolling Contact Assembly Rolls over the Regulator Coils both side for plus minus purpose for continuous current having trouble free working life more than 15 years with losses less than 1% at rated current.

In 1990 we developed the linear regulator

This is suitable for continuous load with lesser losses i.e. 1% maximum at rated current. The material used in linear voltage regulator i.e. copper, lamination and size is three times the conventional type voltage regulator.

Energy Audit

Any power consumer can do Energy audit or check the voltage variation in their premises with the help of digital power analyzer, which is easily available in the market at a very nominal cost (approx. Rs. 6,000/, with accessories & Software). It records the data after every 15 min. interval for 7 days as shown in the chart below:

Date & Time		System Voltage (Volt) in each phase			SystemCurrent (Amps) in each phase			Power consumption
Date	Time	Rn	Yn	Bn	Ir	Iy	Ib	kW
xx/xx/xxx	00.00	234	235	240	85	90	90	50

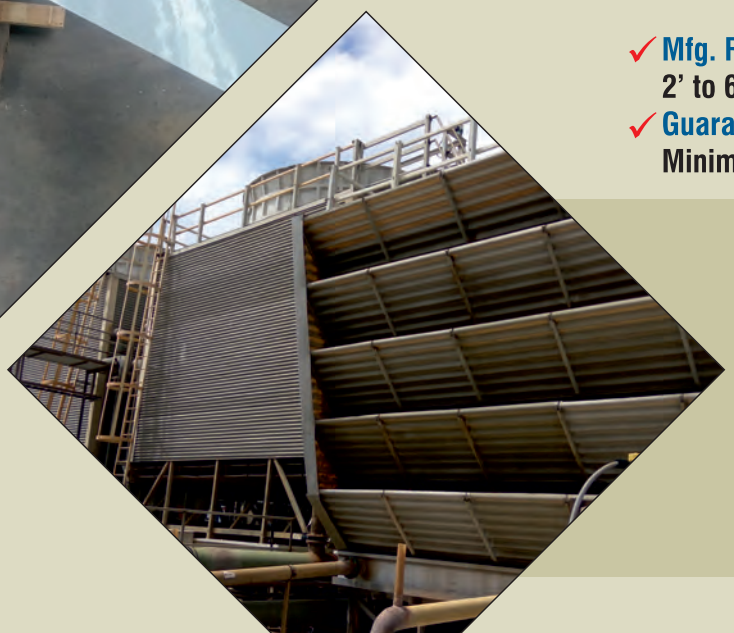
According to the voltage variation / current pattern, a consumer can decide whether he/she needs the Automatic Voltage Controller or not.

The payback period

1. The benefit of installing an Automatic Voltage Controller is to reduce the failure rate of costlier electrical/ electronics' equipment.
2. The Automatic Voltage Controller is not a power saving device. This is added advantage at high voltage.
3. The input voltage increases payback period decreases accordingly may be 4-12 months.

Due to not reliable technology of Voltage Regulator available the voltage correction system could not become popular.

For more information:
Contact at email: jemc@jindalelectric.com



ENCON

Manufacturers & Exporters of Energy Saving E-Glass Epoxy FRP Fans & High Efficiency Cooling Tower

- Cooling Towers
- AHU
- Air Fin Coolers
- Radiators
- Man Coolers
- Man Coolers
- Exhaust Systems
- HT Motor Coolers
- Air Cooled Condensers
- Mines Ventilation
- Withering Trough
- Kiln Shell
- P&V Systems
- Humidification Towers
- Transformer Coolers

✓ **Mfg. Range:**
2' to 63' dia

✓ **Guaranteed Energy Savings:**
Minimum 15% to 30%

Head Office:
Unit 907, Marathon Icon,
Marathon Next Gen Campus,
Ganpatrao Kadam Marg, Lower Parel,
Mumbai 400 013. India
Tel.: 91 22 2437 2949 / 2430 6578
Fax: 91 22 2431 0992 / 2432 1929
Email: enconindia@vsnl.com
encon@encongroup.in
Website: www.encongroup.in
www.recondoctpl.com

DIFFERENT LOW VOLTAGE

EARTHING & BONDING SYSTEMS

Earthing is to make an electric connection between a conductive part and a local earth. The connection to local earth can be intentional, or unintentional or accidental and can be permanent or temporary. This article discusses the five main earthing configurations: TN-S, TN-C, TN-C-S, TT, and IT, their structures, advantages, disadvantages, and associated safety protection systems...

Earthing (grounding) is to make an electric connection between a conductive part and a local earth. This is a fundamental concept in electrical installations, providing a path for fault currents and helping ensure electrical safety.

It prevents electric shock hazards, limits overvoltages, and ensures the proper operation of protective devices. There are several earthing systems in use worldwide, primarily classified as TN (Terre-Neutral), TT (Terre-Terre) and IT (Isolated Terre).

Significance of Earthing (Grounding)

- Safety from Electric Shock
- Protection against Electrical Fires
- Equipment Protection
- Voltage Stabilisation
- Legal and Regulatory Compliance

Concept of Earthing (Grounding)

When the neutral for any system is not connected with the earth then it will be known as electrical system without earthing as depicted in figure 1.

Mostly, the galvanised iron is used for the earthing. The earthing provides the simple path to the leakage current and fault current in

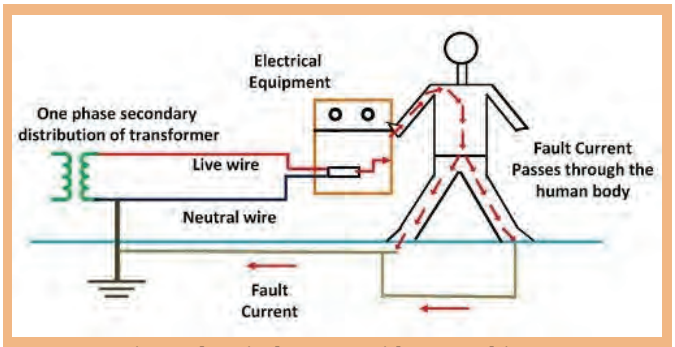


Fig. 1: Electrical system without earthing...

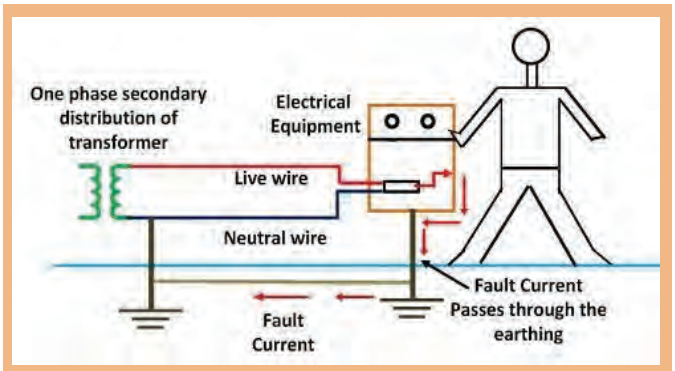


Fig. 2: Electrical system with earthing...

the system. The short-circuit current of the equipment passes to the earth which is assumed to have zero potential. Thus, protects the system equipment and personnel working with these equipment from damage as well as shock current as shown in figure 2.

The system earth resistance should be such during any fault against which earthing is designed to ensure protection i.e., the protective gear must operate to isolate the faulty section – for example by circuit breaker or fuses.

Types of Electrical Earthing

The electrical equipment mainly consists of two non-current carrying parts. These parts are neutral of the system or frame / support structure of the electrical equipment. From the earthing of these two non-current carrying parts of the electrical system, earthing can be classified into two types:

- Neutral (System) Earthing
- Equipment Earthing
- **Neutral (System) Earthing:** In neutral earthing, the neutral of the system is directly connected to earth with the help of some metallic conducting wire. The neutral earthing is also called the system earthing. Such type of earthing is mostly provided to the system that has star winding. For example, the neutral earthing is provided in the generator, transformer, DG set etc., as shown in figure 3.

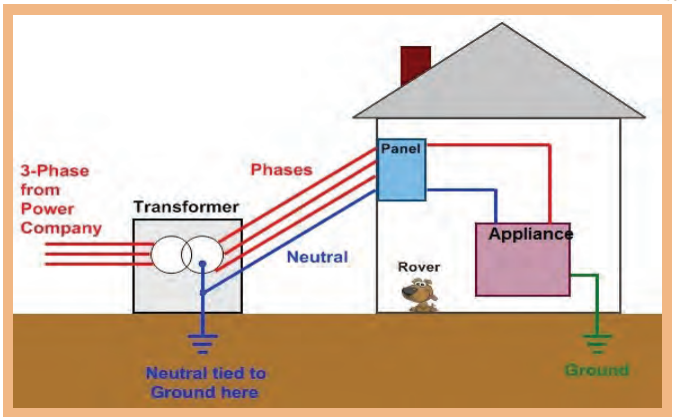


Fig. 3: Neutral and equipment earthing...

- **Equipment Earthing:** Such type of earthing is provided to the electrical equipment. The non-current carrying part of the equipment like their metallic frame is connected to the earth by the help of the conducting wire as shown in fig 3. If any fault occurs in the apparatus, the short-circuit current to pass the earth by the help of wire. Thus, protect the system from damage.

Classification of earthing system

A low voltage (LV) distribution system may be identified according to its earthing system. These are defined using the five letters:

1. T (direct connection to earth),
2. N (neutral),
3. C (combined),
4. S (separate) and
5. I (isolated from earth).

The first letter denotes how the transformer neutral (supply source) is earthed, while the second letter denotes how the metal work of an installation (frame) is earthed. The third and fourth letters indicate the functions of neutral and protective conductors respectively.

There are three possible configurations:

- **TN:** transformer neutral earthed, frame connected to neutral. The TN system includes three sub-systems: TN-C, TN-S and TN-C-S.
- **TT:** transformer neutral earthed and frame earthed.
- **IT:** unearthed transformer neutral, earthed frame.

TN Earthing System

In a TN earthing system, the supply source (transformer neutral) is directly connected to earth with one or more conductors and all exposed conductive parts of an installation are connected to the neutral or protective earth conductor. The three sub-systems in TN earthing system are described below with their key characteristics.

TN-C Earthing System

TN-C system has the following features:

- Neutral and protective functions are combined in a single conductor throughout the system. (PEN – Protective Earthed Neutral).
- The supply source is directly connected to earth and all exposed conductive parts of an installation are connected to the PEN conductor as shown in figure 4.

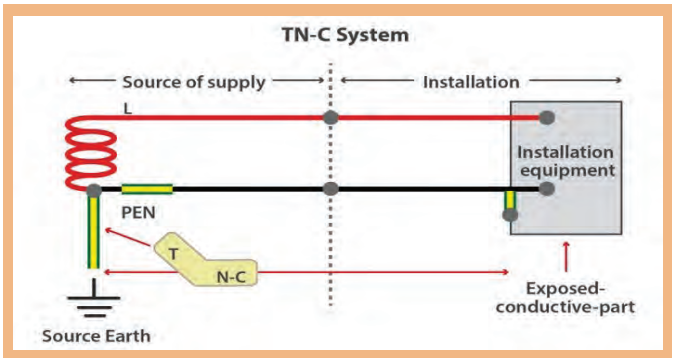


Fig. 4: TN-C earthing system...

Safety Protection:

- Fuses or circuit breakers for overcurrent protection.
- RCDs are generally not effective without separate PE.

Applications:

- Often used in older or budget-limited distribution networks.

TN-S Earthing System

TN-S system has the following features:

- A TN-S system has separate neutral and protective conductors throughout the system.
- The supply source is directly connected to earth. All exposed conductive parts of an installation are connected to a Protective Conductor (PE) via the main earthing terminal of the installation as shown in figure 5.

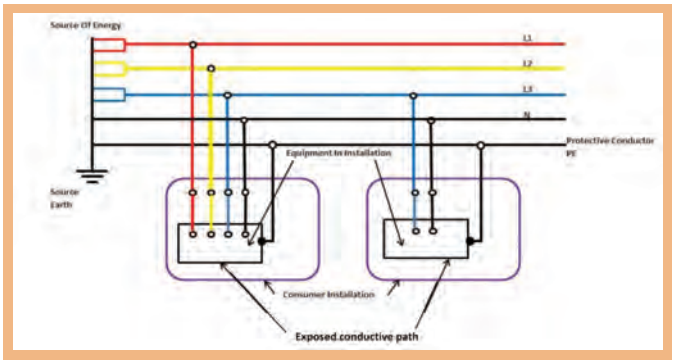


Fig. 5: TN-S Earthing system...

Safety Protection:

- Residual Current Devices (RCDs) or Miniature Circuit Breakers (MCBs) detect faults between live and earth.
- Overcurrent Protection Devices (OCPDs) trip if excess current flows.
- Quick disconnection during earth faults to prevent shock.

Applications:

- Commercial and industrial installations where electrical noise reduction is essential.

TN-C-S Earthing System

TN-C-S earthing system has the following features:

- Neutral and protective functions are combined in a single conductor in a part of the TN-C-S system. The supply is TN-C and the arrangement in the installation is TN-S as depicted in figure 6.
- Use of a TN-S downstream from a TN-C.
- All exposed conductive parts of an installation are connected to the PEN conductor via the main earthing terminal and the neutral terminal, these terminals being linked together.

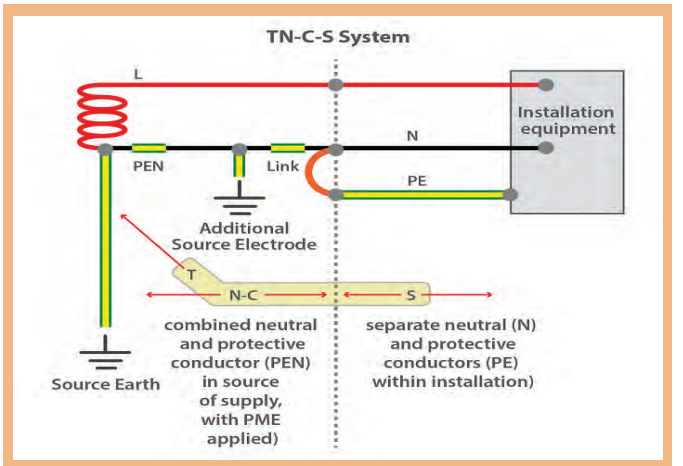


Fig. 6: TN-C-S Earthing System...

This type of distribution is known also as protective multiple earthing and the PEN conductor is referred to as the Combined Neutral and Earth (CNE) conductor.

The supply system PEN conductor is earthed at several points and an earth electrode may be necessary at or near a consumer's installation.

Safety Protection:

- RCDs to detect leakage currents
- Equipotential bonding to reduce touch voltages
- Multiple earthing points to minimise rise in earth potential

Applications:

- Residential, commercial and mixed-use installations

TT Earthing System

In this system, the supply source has a direct connection

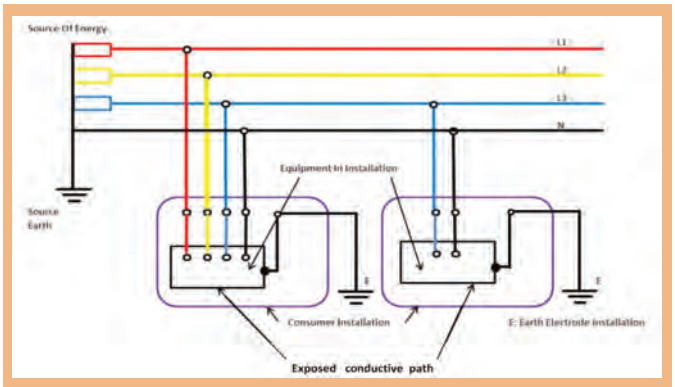


Fig.7: TT Earthing System...

to earth. All exposed conductive parts of an installation also are connected to an earth electrode that is electrically independent of the source earth as shown in fig 7.

The fault loop impedance is higher, and unless the electrode impedance is very low indeed.

Safety Protection:

- RCDs are mandatory, typically 30 mA for personal protection
- Earth electrodes must have low resistance to ensure proper fault current flow
- Earth loop impedance testing is crucial during installation

Applications:

- Rural or remote areas
- Small buildings with no PME availability

IT Earthing System

In this system, the supply source is either connected to earth through deliberately introduced high earthing impedance (Impedance earthed IT system) or is isolated from earth. All exposed conductive parts of an installation are connected to an earth electrode as shown in figure 9.

The conductive parts including metal body of the installations are connected to earth through one or more local earth electrodes. These local electrodes do not have any direct connection to the source.

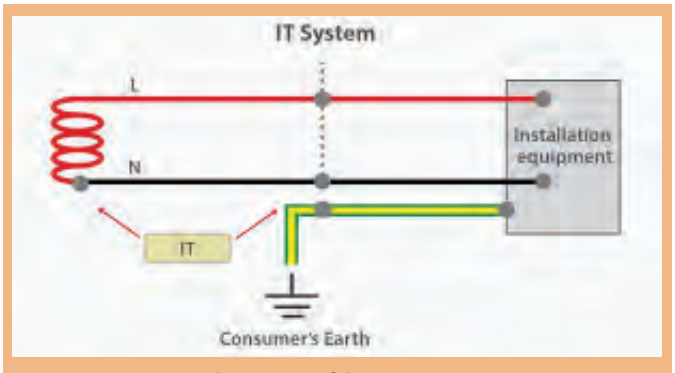


Fig.8: IT Earthing System...

It is pertinent to mention here that single phase IT system shown in figure 8 is not used in India (Except in special locations).

Safety Protection:

- Insulation Monitoring Devices (IMDs) detect the first fault without shutting down the system.
- Alarms or indicators alert personnel of insulation failures.
- RCDs and MCBs may be used for secondary fault protection.

Applications:

- Hospitals (operating theatres)
- Mines, military, ships
- Data centres

Comparison of all earthing systems

Comparison of all earthing systems based on earth fault loop impedance, RCD preferred, need earth electrode at site, PE conductor cost, etc., has been carried out as follows:

Table 1- Comparison of all earthing systems

Earthing System Conditions	TN-C	TN-S	TN-C-S	TT	IT
Earth Fault Loop Impedance (EFLI)	Low	Low	Low	High	Highest
RCD Preference	No	Optional	Optional	Yes	N.A.
Need of Earth Electrode at Site	No	No	Optional	Yes	Yes
PE Conductor Cost	Least	Highest	High	Low	Low
Risk of Broken Neutral	Highest	High	High	No	No
Safety	Least safe	Safest	Safe	Safe	Less Safe
Electromagnetic Interference	High	Low	Low	Least	Least
Safety risks	Broken neutral	Broken neutral	Broken neutral	High loop Impendance (Step Voltages)	Double fault over voltage

Earthing and bonding difference & significance

Earthing and bonding are both vital safety measures in electrical systems but serve different purposes. Earthing connects electrical equipment or systems directly to the earth to safely dissipate fault currents, preventing electric shock and equipment damage. It provides a reference point of zero potential and ensures protective devices operate correctly during faults (As already discussed in detail).

Bonding, on the other hand, involves connecting all exposed and extraneous conductive parts together to maintain equal potential and eliminate voltage

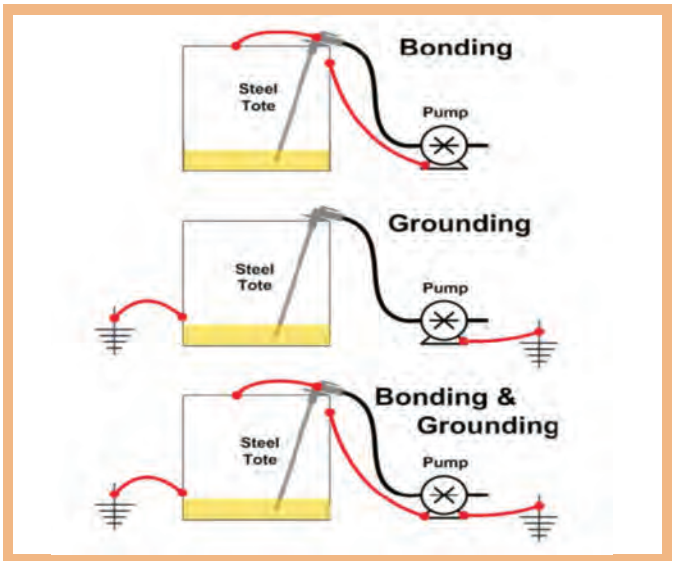


Fig.9: Bonding & Earthing Concept...

differences between metal parts. While earthing directs fault current to the ground, bonding prevents electric shock by ensuring all accessible conductive surfaces remain at the same potential. (Refer figure 9)

Equipotential bonding in an electrical system is the practice of electrically connecting all exposed and extraneous conductive parts to maintain the same potential and minimise voltage differences. This connection ensures that, in the event of a fault, no dangerous potential exists between metallic parts that a person might touch simultaneously. Let's understand the terms exposed and extraneous conductive parts. (Refer figure 10)

Protection: Must be connected to the main earthing terminal via equipotential bonding to ensure they are at the same potential as exposed parts, preventing dangerous touch voltages.

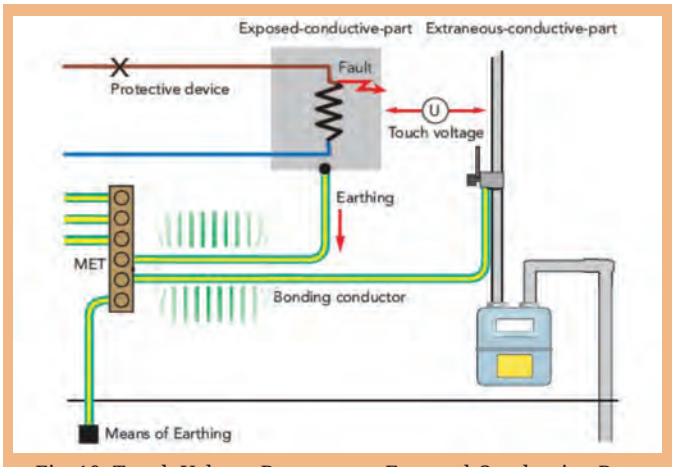


Fig. 10: Touch Voltage Between an Exposed-Conductive-Part and an Extraneous-Conductive-Part...

Equipotential bonding is achieved through main and supplementary bonding conductors. Its primary purpose is to enhance safety by reducing the risk of electric shock, providing a low-resistance fault path, and enabling protective devices to disconnect faulty circuits promptly.

Main bonding and supplementary bonding are essential safety measures in electrical installations designed to prevent electric shock and ensure proper operation of protective devices. Main bonding involves connecting the main protective conductor to the main metallic parts of a building, such as gas, water, or structural steel pipes. This creates a common reference point for all metallic parts, ensuring that, in the event of a fault, no dangerous voltage difference exists between them. It also allows protective devices like circuit breakers or fuses to operate quickly by providing a low-resistance fault path.

Supplementary bonding, on the other hand, is the additional connection between exposed conductive parts and nearby extraneous conductive parts in locations where the risk of electric shock is higher, such as bathrooms or kitchens. It equalises potential differences within a localised area, reducing the risk of current passing through a person who simultaneously touches two metal surfaces at different potentials. (Refer figure 11).

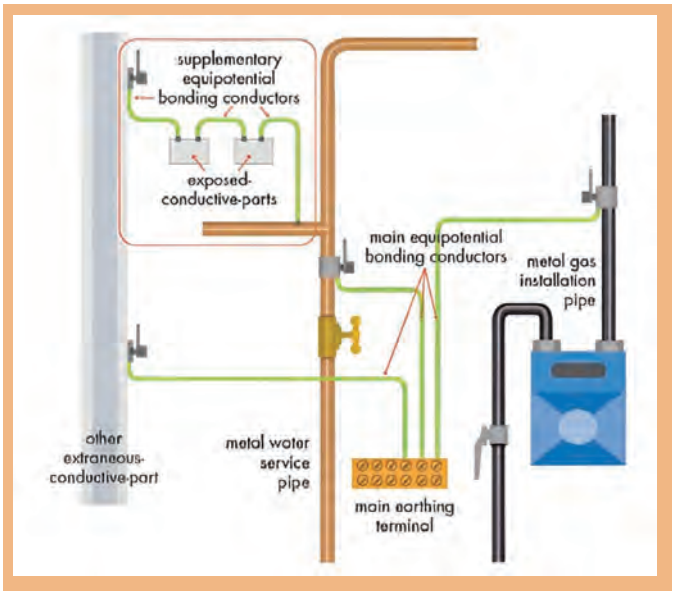


Fig. 11: Main and Supplementary Bonding Concept...

Regulation 18 – Earthed terminal on consumer premises

What it requires:

The electricity supplier must provide and maintain a proper earthed terminal on the consumer's premises.

Fig. 12: Explanation of REG.18 of CEA Safety Regulation...

For installations with voltage exceeding 250 V, the consumers must provide their own earthing systems (an independent electrode) that must be inter-linked with the supplier's earthed terminal via a suitable link.

The consumer must take all reasonable precautions to prevent mechanical damage to the earthing terminal and its lead belonging to the supplier.

Why it matters:

- Proper earthing is critical for protecting persons and equipment from fault currents and electric shocks. (Refer figure 12)
- Ensures that the supplier and consumer's earthing systems are coordinated, reducing risk from improper or missing earth connections.

Key points to remember:

- Applies to every consumer's installation where supplier provides supply.
- If voltage > 250 V, consumer's own electrode is mandatory and must link with supplier's earth.
- Both supplier's and consumer's earth arrangements must be maintained and protected from damage.

Conclusion

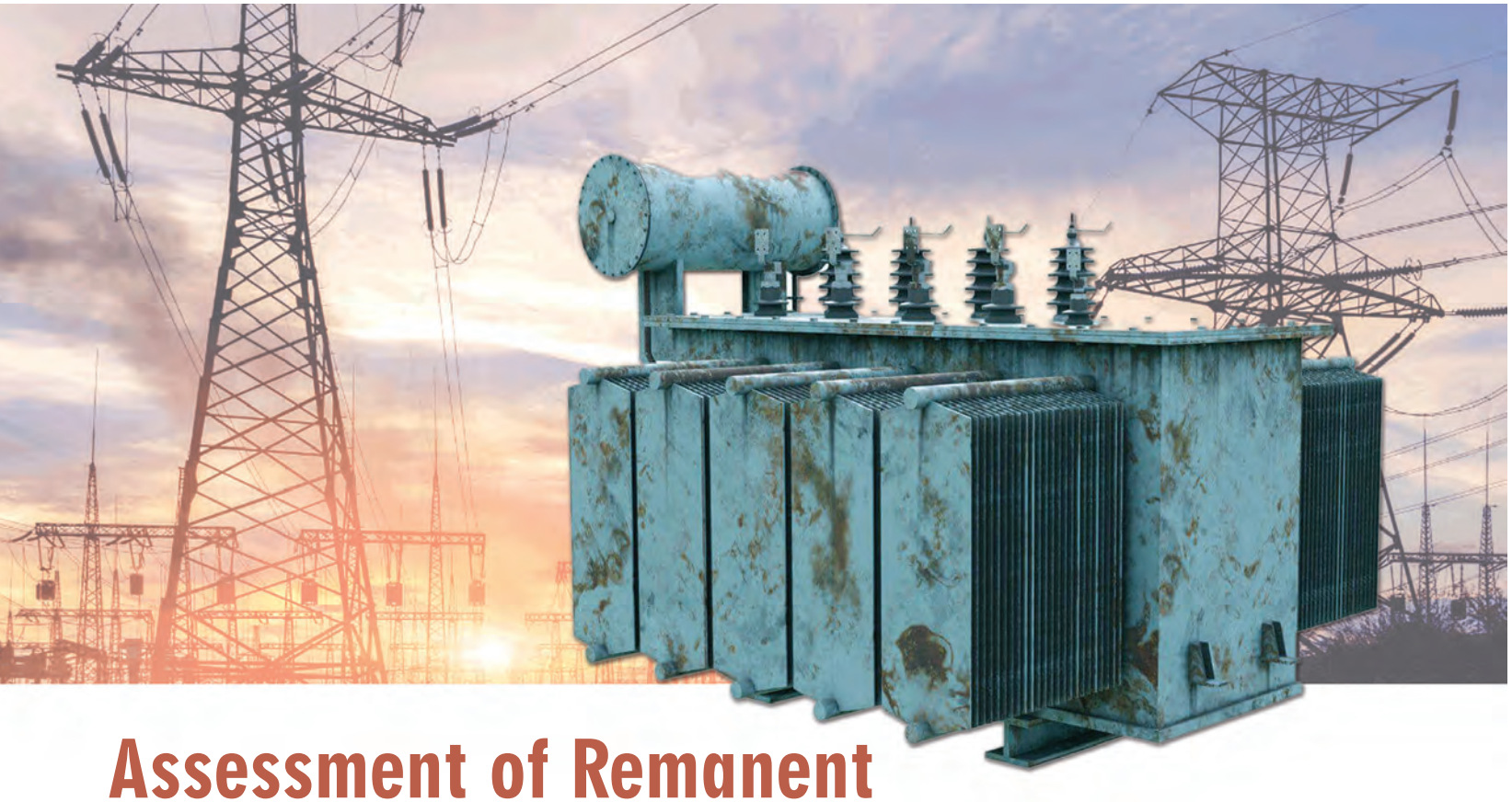
Choosing the right earthing system is essential for ensuring electrical safety, reliability, and compliance with regulations. Each system has its unique structure, benefits and associated protection mechanisms.

Proper design, installation and maintenance of the earthing and protection systems are crucial for minimiing electrical hazards, ensuring user safety.

Earthing and bonding are two different ways of providing safety to electrical systems from sudden and unexpected leakage or discharge of current due to various reasons. Though earthing is a more common term we come across, bonding is also equally important in all electrical systems. At the same time, electrical bond alone does not ensure complete protection, but along with grounding, it helps to discharge the extra current to the ground thus making the system safe.

As per regulation 18 of CEA safety regulation it must be ensured that the supplier and consumer's earthing systems are coordinated, reducing risk from improper or missing earth connections.

Dr. Rajesh Kumar Arora obtained his B. Tech. and M.E. degrees in Electrical Engineering from Delhi College of Engineering, University of Delhi. He completed his PhD in grounding system design from UPES, Dehradun. He is also a certified Energy Manager and Auditor and has worked in 400kV and 220kV Substations for more than 14 years in Delhi Transco Limited (DTL). He has also worked as Deputy Director (Transmission and Distribution) in Delhi Electricity Regulatory Commission (DERC). Presently he is working in D&E (Design and Engineering) department of DTL.



Assessment of Remanent Life-Expectancy of Old Transformers

The author has analysed many old transformers ranging from 16 MVA to 40 MVA, in the M.P. Power Transmission Utility. MPPTCL (M.P. Power Transmission Utility) had identified the old transformers having bad health-status and had replaced them expeditiously...

The life-expectancy of Power Transformers, is assumed to be 35-40 years. However, there is no literature expressively quantifying the same. Unforeseen failures of old transformers in the Grid-network result into system disturbance or cascade trippings. Therefore, it is of utmost importance to obviate such situations to safe-guard the grid-system from the aforesaid disturbances and losses.

M.P. Power Transmission Utility has guidelines for selection of all aging transformers for assessing the remaining life expectancy thereof.

In-view of above, it is essential to assess the remaining serviceable life of the transformers for rendering faithful service which have rendered continuous service over 20 years in a Grid system and to timely replace them with new ones, if found unserviceable.

Following criteria was adopted by the M.P. State Transmission Utility for selection of all such aging transformers for assessing the health-status thereof;

- Which had rendered continuous service for more than 20 years.
- Deterioration trend in IR and PI values, observed.
- DGA showed increasing trend in the key gases and also increasing trend in CO and CO_2 gases with reference IEC 60599.
- Percentage of relative water saturation in the transformer oil: > 15 %,
- DP value <250.

This article is to narrate the methodology to assess the health-status of the aging transformers. While assessing the same, if health-status of any of them was found deteriorated and approaching towards end of its life, was recommended for removal from service and to be replaced with a healthy transformer.

Causes for deterioration of solid and liquid insulations

Deterioration in overall insulation is attributed to the following:

- Improper monitoring and maintenance of the breathing system.
- Increase in moisture contents in the oil above 20 ppm.
- Continuous over-loading of transformers, fall in DP value nearing 200.
- Sustaining many through faults conditions.
- Sustaining switching and lightening surges.
- Improper/irregular maintenance practices.

Percentage of water saturation in oil

The quantity of dissolved and dispersed water in mineral oil is significant for two reasons:

- Presence of polar water molecules in the mineral oil adversely affects the dielectric properties of the mineral oil.
- The amount of moisture in the oil can be reflective of amount of moisture in the paper insulation. The solubility in mineral oil is temperature-dependent. Therefore, a statement as mg/kg of water in the oil without temperature information would not be adequate.

The calculation of percentage of water saturation is [(mg/kg water in insulating liquid)/(mg/kg of water in insulating liquid at saturation)] × 100, in other words (ppm of water/So) has greater significance as it indicates the possibility of free water formation in the oil.

Free water in oil

'Free water' exists in the form of droplets if the water content in oil exceeds the saturation level. In cellulose materials, free water may exist in macropores. In addition, following are the basic reasons for increasing the water contents in oil:

- Residual moisture in the thick structural components not removed during factory drying-out or moistening of insulation surface during assembly.
- Inhaling atmospheric air through fused silica-gel while oil volume shrinks during cold and moist nights and during off-peak hours of the day, resulting into poor dielectric strength of oil.
- Aging (decomposition) of cellulose and oil.
- Table 1 of IEEE Std 62-1995 gives general guidelines for interpretation of data expressed in % of water saturation in oil vis-à-vis condition of dryness of paper insulation.

Table1: interpretation of data expressed in % of saturation...

% of water saturation in oil	Condition
0-5	Dry insulation
6-20	Moderate to wet. Lower numbers indicate fairly dry to moderate levels water in insulation, whereas values towards the upper limit indicate moderately wet insulation.
21-30	Wet
>30	Extremely wet

Formula for solubility of water in oil and specimen calculation

$$\text{Log}_{10}\, S_O = \left(\frac{-1567}{K}\right) + 7.0895$$

Where:

- S_O is the solubility of water in mineral oil.
- K is the absolute temperature in Kelvins (^{O}C+ 273).
- °C is the oil temperature in Celsius at the time of sampling

$$\% \text{ saturation} = \left(\frac{\text{ppm of water}}{\text{So}}\right) \text{ x } 100$$

Specimen calculation for % saturation

Water content = 16 ppm,
Temperature of top oil = 30 deg. C
Temperature in Kelvin = 30 deg. C + 273 = 303 K,
Log_{10}So = (-1567/303)+7.0895 = -5.1716 +7.0895 = 1.9197.
So = $10^{1.9197}$.
So = 82.775,
Therefore % saturation = (16/82.775) x 100 = 19.32%

Solid insulation in the transformers

The Kraft paper is a major solid dielectric material used for conductor wrappings, barrier boards, spacers and clamps (in compressed or resin-bonded forms). The major constituents of the soft wood craft paper are cellulose (80%), hemi cellulose (12%) lignin (about 8%) and some mineral substances. The structural formula of cellulose is as shown in the Fig. 1.

Three most common degradation factors for cellulose have been identified and they are thermal, oxidative, and hydrolytic. When cellulose is subjected to a temperature of 200°C, the beta linkages (glycosidic bonds) tend

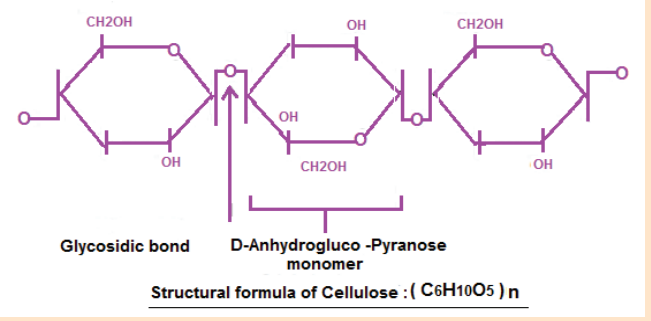


Figure 1: Structural formula of cellulose $(C_6H_{10}O_5)_n$...

to break and open the glucose molecule rings and thereby lose mechanical strength. The by-products of this reaction are;

- Free glucose molecules
- Moisture
- CO & CO_2
- Organic acids

Presence of oxygen promotes oxidation and cellulose molecules have a tendency to oxidise. The reaction of oxidation on the cellulose causes the glycosidic bond to weaken and it can cause scission of the cellulose molecule chain. The oxidation of hydroxyl produces carbonyl (aldehydic) and carboxyl (acidic) compounds. Moisture is also a by-product of this oxidative reaction.

The moisture produced as explained above is also transferred to the oil.

Furans

As stated earlier, the byproducts of paper insulation (cellulosic insulation) degradations are;

CO, CO_2, moisture, organic acids, and free glucose molecules.

The free glucose molecules further degrade into aromatic components known as Furans.

Following are the Furans,

- 5H2F (5-Hydroxymethyl-furaldehyde) is an unstable compound and can decompose further into other furans as follows:
- 2-Furaldehyde (2FAL)
- 5 Methyl-2-Furaldehyde (5M2F)
- 2-Acetyl furan (2ACF)
- Furfuryl alcohol (2-FOL).

However, all the above components except 2 FAL are not very stable under operating conditions in the transformers. Their life-span is a few months only, thereafter they degrade into 2 FAL which remains stable for several years. The molecular structure of 2-Furaldehyde (2FAL).

Mechanical properties of insulating paper- evaluation thereof

The mechanical properties of insulating paper can be established by direct measurement of its tensile strength or Degree of Polymerization (DP). These properties are used to evaluate the Life expectancy of a Transformer. Direct measurement thereof is not practically possible for the in-service transformers as analysis of paper-insulation for its DP value requires removal of a few strips of paper from the aging Transformers.

To overcome the constraint mentioned earlier, the learned scientists of Transformer- Chemistry have innovated that "when cellulose molecules de-polymerise (break into smaller lengths or ring structures) the chemical compounds known as furans are formed" as stated earler.

Finally, all the other Furan components degrade to Furan:2-Furaldehyde (2FAL), which remains as stable DP for years together.

Formula-DP Vs. furan contents

Some Scientists of Transformer Chemistry had innovated equations to calculate DP value with the help of quantity of 2 FAL in ppm or ppb found in the mineral oil in the serving transformer. However, Chendong's formula for evaluating DP with furan(2FAL) was found suitable.

Chendong's equation;

$$DP = \frac{\log(2FAL) - 1.51}{-0.0035}, \text{ where 2FAL in ppm}$$

Figure 2: Chendong's formula for evaluating DP with furan (2FAL)...

Note:

i. ppm = Parts per million = 1/106 ,
ii. ppb = Parts per billion =1/109,
iii. 1ppm =1000 ppb.

Out of graphical representation of furan Vs. DP of all the scientists. Chengdong's curve was largely accepted.

Remnant-life expectancy of transformers in % with reference to furan (2 FAL) and DP value

Since, it is difficult to obtain paper samples for evaluation of the DP from in-service EHV Transformers, the method of estimation of the DP and the remaining/residual life of the Transformers is assessed, by measuring the

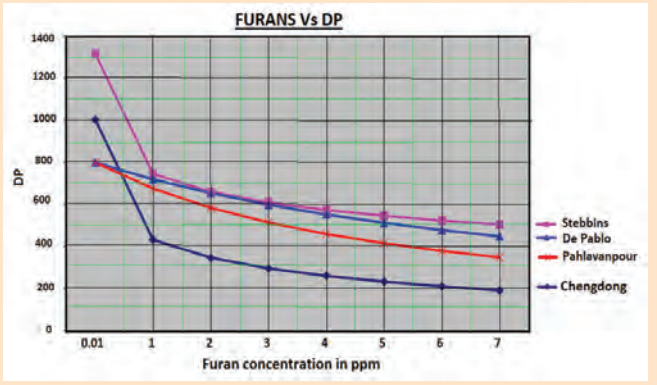


Figure 3: Graphical representation of Furan vs DP of different scientists...

Furan content 2 FAL (2-Furaldehyde) in ppm/ppb in the Transformer oil of the transformers.

Percentage remnant life of the transformers with respect to DP value is as shown in the table 2, it is almost in line with the Chengdong's model.

Table. 2: 2 FAL (ppb) Vs.DP...

2 FAL (ppb)	Estimated Degree of Polymerization (DP)	% of Remnant life	Interpretation
58	800	100	Normal aging
130	700	90	
292	600	79	
654	500	66	Accelerated aging
1464	400	50	
1720	380	46	
2021	360	42	
2374	340	38	Excessive aging Danger Zone
2789	320	33	
3277	300	29	
3851	280	24	High risk of failure
4524	260	19	
5315	240	13	End of life of paper
6245	220	7	
7337	200	0	

Ref: An introduction to the Half Century Transformer by The Transformer Maintenance Institute. S.D. Myers Co. 2002.

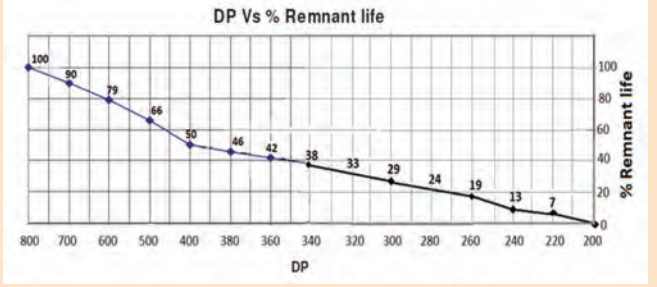


Figure 4: Graphical representation of the DP Vs % Remanent life...

Criteria for selection of old transformers for evaluating % remanant life expectancy

- Transformers that have served for more than 20 years.
- Deterioration in IR and PI values.
- DGA showed increasing trend in the key gases and also increasing trend in CO and CO_2 gases with reference IEC 60599.
- Water saturation in oil if found >*15 %.
- DP value <250.

*Note: this figure is selected looking at Table 1, indicating guidelines for interpretation of % saturation of water in oil.

Selection of transformers for evaluating % remnant life expectancy

A sample list of a few old transformers that have rendered continuous service for more than 20 years with the calculated % saturation of water in oil at sampling temperature is shown in Table 3.

Table.3

Sr. No.	Sub-Stn. name	Name of transformer	Transformer serial No.	Water content (ppm)	Temp.in deg. C	Calculated % Saturation	Remarks
1	132 KV S/s Kymore	16 MVA 132/33 KV NGEF	2800034714	21	50	12.13	CAL at 50 °C
2	132 KV S/s Kymore	20 MVA 132/33 KV BHEL	6004548	27	51	15.60	CAL at 50 °C
3	132 KV S/s Kymore	5 MVA 33/11 KV UE	183775	38	48	21.95	CAL at 50 °C
4	220 KV S/s Jabalpur	40 MVA 220/132 KV BHEL	6004131	20	50	11.56	CAL at 52 °C
5	220 KV S/s Jabalpur	40 MVA 220/132 KV BHEL	6004129	24	52	12.94	CAL at 50 °C

Case study 1; (Please refer Table: 3)

The transformer in Sr, no.2; 20 MVA 132/33 kV BHEL transformer bearing Sr. no.6004548 at 132 kV S/S, Kymore.

Calculation of % of solubility of water in oil:

Log_{10} So = (-1567/K) +7.0895,

Where;

- So is the solubility of water in mineral oil,
- K is the absolute temperature in Kelvins (°C + 273),
- °C is the oil temperature in Celsius at the time of sampling,
- % saturation = (ppm/So) x 100,
- Oil temperature = 50 °C and moisture content in the oil 27 ppm,

- K = 50 + 273 = 323 °K

  Therefore, Log_{10} So = (-1567/323) +7.0895 = 2.2382

  So = $10^{2.2382}$ = 173.06135,

  Therefore, % saturation = ppm/So x 100 = (27/173.06135) x 100 = 15.601 %

  Since *15.601% > 15 %, this transformer is identified for removal from the system.

Furan Analysis Report

It's 2 FAL was reported to be 3570 ppb, the DP is around 260 as per curve at figure 4 i.e., the % remnant life is 19%.

Recommendation

- Since % saturation of water in oil was 15.601%,
- % Remnant life found to be 19% in the range of high risk of failure.

Looking to above, this Transformer was strongly recommended for removal from the System.

Case study 2; (Please refer Table: 3)

Transformer at Sr.no.5; 40 MVA, 220/132 kV, BHEL Transformer bearing sr.no.6004129 at 220kV S/S Jabalpur.

Calculation of % of solubility of water in oil:

Log_{10} So =(-1567/K) +7.0895,

Where;

- So is the solubility of water in mineral oil,
- K is the absolute temperature in Kelvins (°C + 273),
- °C is the oil temperature in Celsius at the time of sampling,
- % saturation = (ppm/So) x 100,
- Oil temperature = 52°C and moisture content in the oil 24 ppm,
- K = 52 + 273 = 325 °K

Therefore, Log_{10} So = (- 1567/325) + 7.0895 = 2.268

So = $10^{2.268}$ = 185.353,

Therefore, % saturation = ppm/So x 100 = (24/185.353) X 100 = 12.94%

Therefore, % saturation is within the bench mark of 15%.

Furan Analysis Report

Its 2 FAL was reported to be 1520 ppb, the DP is around 380 as per curve at figure 4 i.e., the % remnant life is 46% indicating accelerated ageing.

Recommendation

- Since % saturation of water in oil was 112.94%,
- % Remnant life found to be 46 % in the range of accelerated ageing.

Looking to above, this Transformer was recommended for continuance in the circuit, however, monitoring of condition should be done every year.

Points of importance to be kept in mind

- The concentration of Furanic component 2 FAL (2 Furaldehyde) gives an indication of the condition of paper in terms of DP(Degree of Polymerisation), while rate of change of Furan concentration can indicate the rate of aging of paper.
- High concentration of 2 FAL (2 Furaldehyde) is an indication of aged cellulosic insulation.
- Average DP value of new kraft paper is 1,000 to 1,200. Breaking down of cellulose during manufacturing and transformer drying process brings down the DP value to 800.
- DP value < 200 indicates extensive loss of paper degradation approaching the critical value i.e., threat of failure of the aged transformer.
- The main advantage of using this technique as a diagnostic tool is that these Furan compounds are degradation by-products specific to paper which are soluble in the Transformer Oil but cannot be produced by the oil itself. It can be used as complementary test in conjunction with % saturation of water in oil.

Some of the specimen pictures are depicted in the figures 5(a) & (b), 6, 7 and 8.

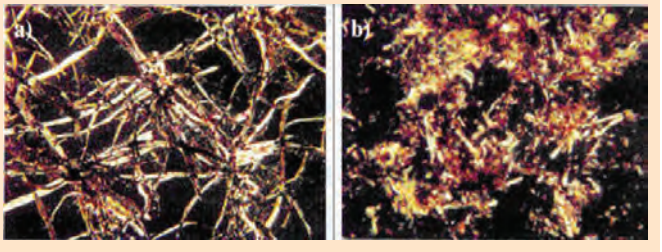


Figure 5 (a): Insulation structure of healthy paper. (b) depicts structure of paper when the DP value fall down to <200...

Figure 6: Deterioration of paper DP value <200 in the distribution transformer windings...

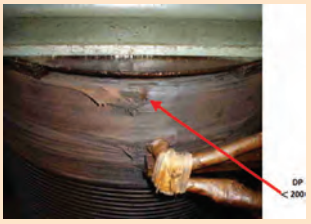


Figure 7: Showing effect of DP value<200 in a power transformer...

Figure 8: Showing effect of DP value<200 in a power transformer...

Conclusion and suggestions

This methodology is found to be effective in MPPTCL. It is suggested that the Power Utilities may follow suit.

Degree of Polymerization (DP) is used to evaluate the Life expectancy of a transformer through Furan analysis. Direct measurement of DP is practically not possible for the in-service transformers as analysis of paper insulation for evaluation of DP value requires removal of a few strips of paper from the aging Transformers. Therefore, the analysis of oil for furan contents is a 'Non-invasive test'.

This test should be included in the transformer's maintenance schedule at least once in 2-years of the transformers that have served >20 years and data should be reviewed in conjunction with DGA, fluid insulation tests and maintenance history.

The main advantage of using this technique as a diagnostic tool is that these Furan compounds are degradation by-products specific to paper only, which are soluble in the transformer oil but cannot be produced by the oil itself.

Er. K. K. Murty possesses B.E.(Hons) Elec. Engg., FIE, CE (India), Member-CGRE. He is a former Chief Engineer & HOD (Testing & Commun.), M.P. Power Transmission Co. Ltd. Jabalpur. He has served in MPSEB & MPPTCL, Jabalpur for 33 years at different levels from the Assistant Engineer to the Chief Engineer. Besides professional engagements, he has authored a book titled 'Compendium of Articles on EHV Substations & Protections for Budding and Practicing Engineers of Transmission Utilities.' Presently he is rendering services as Sr. Visiting /Guest Faculty, for the In-house Training Institutions of the MPPTCL, Jabalpur and the M.P. East Zone, DISCOM, Jabalpur.

APAR Industries Appoints C. Shrotri as New CEO – Cables Solutions

APAR Industries Limited, a global leader in cables, conductors and specialty oils, has appointed Chandrashekhar Shrotri as the new Chief Executive Officer (CEO) of its Cables Business, effective from December 4, 2025.

Shrotri joins APAR with four decades of international experience in the electrical and power sectors, spanning roles in P&L leadership, manufacturing, R&D transformation, sales, product management, and multi-country business operations. Prior to joining APAR, he served as Segment CEO – Region IAA (India, ASEAN & Africa) at Siemens.

He has contributed to national industry bodies such as IEEMA, BIS and CII, and has been part of executive leadership programs at IIM Bangalore, Harvard Business School, and Siemens Leadership Excellence (Germany & China).

Speaking on Shrotri's appointment, Kushal Desai, CMD, APAR Industries, said, "Mr. Shrotri's global experience, customer-centric mindset and deep operational expertise will play a pivotal role in shaping the next phase of growth for our Cable Solutions Business. His appointment reinforces APAR's commitment to strengthening our global footprint, driving product innovation, and creating value for customers worldwide."

Expressing his feelings, Shrotri said, "I am honoured to join APAR at a time when the company is poised for significant growth in both India and global markets. I look forward to working with the teams to enhance customer trust, accelerate digital and manufacturing transformation, and build on APAR's strong legacy."

CONTEC Launches BX-M4600 Series: Fanless Industrial PC for Smart Manufacturing

As India advances toward Industry 4.0, the demand for rugged, high-performance computing platforms is growing across manufacturing and infrastructure. Addressing this need, CONTEC, a Japanese leader in industrial computing, has introduced the BX-M4600 Series—a fanless embedded PC designed for industrial edge applications.

Powered by Intel® 13th Gen Core™ processors (i7/i5/i3-13700TE), the BX-M4600 features a hybrid architecture combining Performance and Efficient cores for optimal performance and energy efficiency. Its Intel UHD Graphics 770, based on Xe architecture, supports up to 32 execution units and multiple display pipelines—ideal for digital signage and multi-stream video processing.

Engineered for industrial reliability, the BX-M4600 operates in temperatures from 0°C to 55°C, supports 9–36VDC power input, and complies with EN61000-4-2/4-5 standards. It runs Windows 11 IoT Enterprise LTSC 2024, ensuring long-term OS support.

Storage is flexible and secure with dual front-access SATA bays supporting RAID mirroring, TPM-based encryption, and secure boot. Extensive I/O includes 2× 2.5GbE LAN, 6× USB, DisplayPort, DVI-I, 4× serial ports, GPIO, and audio, enabling seamless integration with industrial systems.

The fanless design ensures silent, dust-resistant operation, while CONTEC's custom BIOS allows deep-level customization. Built with readily available components, the BX-M4600 is ideal for factory automation, control systems, edge computing, and smart infrastructure.

More information: E-mail: info@in.contec.com, Website: www.in.contec.com

Magnum Ankush MaK-1 DOL Motor Starter: Robust Control & Protection for Three-Phase Motors

In the realm of motor control and pump management, reliability and safety are paramount. The Magnum Ankush MaK-1 DOL Motor Starter emerges as a standout device — engineered to deliver dependable switching and comprehensive protection, all wrapped in a rugged enclosure built for the demands of industry and agriculture alike.

Built for Performance and Longevity

1. At its core, the MaK-1 starter is built from heavy-duty components designed for **durability**. Its powder-coated mild-steel enclosure ensures **resilience** even in rough operating environments.
2. The contactor inside delivers **precise, clean switching** — with silver-tipped contacts and carefully calibrated contact carriers to ensure stable, **long-term performance.**
3. Further, the overload relay (O.L. relay) integrated within the starter offers dependable protection against over-current — safeguarding motors from electrical stress and increasing the lifespan of connected equipment.

Safety & Smart Design Features

a. What sets the Magnum Ankush MaK-1 apart from many basic DOL starters is its built-in **protection against electrical anomalies**. It incorporates a "preventor" unit — branded as the "Bhaiyya" S.P. Preventor — that guards the motor against single-phasing and reverse-phase conditions.

b. Moreover, for added user convenience, the starter offers **Auto-Start** capability: in the event of a power interruption, the motor will automatically restart once power resumes and voltage stabilization time (max of 30 seconds) has elapsed — eliminating the need for manual intervention.

c. Flexibility is also baked in. Users can operate the device in **Auto, Manual**, or **Bypass (Preventor)** modes — giving them the leverage to choose the control behaviour that best suits their application.

Technical Snapshot

- **Phase:** Three-phase
- **Power Handling:** Up to **10 HP / 32 A**
- **Coil Voltage:** 440 V (suitable for 280V to 440 V supply)
- **Enclosure & Construction:** Powder-coated mild-steel; robust for industrial and agricultural use.
- **Terminal Capacity:** Supports wiring up to 1 × 16 mm^2 or 2 × 10 mm^2 conductors.
- **Environmental Tolerance:** Operates across a wide temperature range (–25°C to +55°C), making it suited for diverse conditions.

Ready for Diverse Applications

Thanks to its build and specifications, the Magnum Ankush MaK-1 is ideally suited to control three-phase motors such as pumps used in agriculture (submersible/open-well), industrial pumping, fans, compressors, mixers — in fact, any application requiring reliable start-stop control, overload protection, and phase safety.

Industries drawn to this starter appreciate that they're sourcing directly from manufacturer — ensuring consistent quality, transparent pricing, and easy availability of spare parts.

Final Word

The Magnum Ankush MaK-1 DOL Motor Starter stands out as a smart blend of rugged engineering, safety features, and user-friendly design — well suited for the demands of agriculture, industry, and water-pumping operations across India. For operations that depend on consistent motor performance, this starter offers the peace of mind that comes with built-in safeguards, reliable over-current protection, and robust construction.

It is a product that speaks to endurance — not just in hours of operation, but in long-term reliability and control.

For more information: Email: sales@kalpcontrols.com, Website: www.kalpcontrols.com

KALP CONTROLS

MAGNUM®
More Power, Better Controls.

Salient Features

Precision matched contact tips for Long **Mechanical Life**

Trip tested Relay for **Overload Protection** of your Motor

Silver tipped contacts for **Best Electrical Life**

Vacuum impregnated wide band voltage coil for **Flawless Performance.**

Mild Steel enclosure - duly powder coated **Robust build and finish**

Magnum DOL Motor Starter - MaK-1

Presently Supplying to 10+ OEM and 70+ Dealers

We Offer:

DOL & SD Starters, Pump Motor Control Panels, Contactors, O.L. Relays, Kit-Kat Fuse, S.P. Preventors and others

OEM and Dealer Enquiries solicited

THE DIARY

INDIA ENERGY WEEK

Date: 27 – 30 January 2026
Location: Goa, India
Email: sales@indiaenergyweek.com

REV EXPO 2026

Date: 9 – 11 January 2026
Location: Chandigarh, India
Contact: +91 8448994989
Email: info@eventage.in

THE SMARTER E INDIA

Date: 25 – 27 February 2026
Location: Gujarat, India
Contact: +91 2242554707
Email: brijesh.nair@mm-india.in

BHARAT ELECTRICITY SUMMIT 2026

Date: 19 – 22 March 2026
Location: New Delhi, India
Email: sales@bharatelectricitysummit.com

RENEWABLE ENERGY EXPO

Date: 12 – 14 February 2026
Location: Chennai, India
Email: info@renewableenergyexpo.biz

ACREX INDIA 2026

Date: 12 - 14 March 2026
Location: Mumbai, India
Contact: +91 8800266290
Email: headtradefairs@ishraehq.in

IN THE JANUARY 2026 ISSUE

ENERGY MANAGEMENT | Energy Storage | Renewable Energy

OM TECHNICAL SOLUTIONS LLP

YOUR ONE-STOP PARTNER FOR

INDUSTRIAL ELECTRICAL AND AUTOMATION SOLUTIONS
TESTING / MEASURING & CONDITION MONITORING INSTRUMENTS

OUR PRODUCT RANGE

- ONLOAD TAP CHANGER
- POWER QUALITY METER
- VACUUM BOTTLE TESTER
- MULTIPOINT ENERGY METER
- THERMAL IMAGING CAMERA
- TRANSFORMER ONLINE DGA
- AUTOMATIC TRANSFORMER ANALYZER
- SYNTHETIC EASTER OIL FOR TRANSFORMER
- UNDERGROUND CABLE AND PIPE LOCATOR
- MULTIFUNCTIONAL SUBSTATION TEST DEVICE
- ADVANCED LIGHTNING PROTECTION DEVICES
- PRECITION MEASURING & MONITORING RELAY

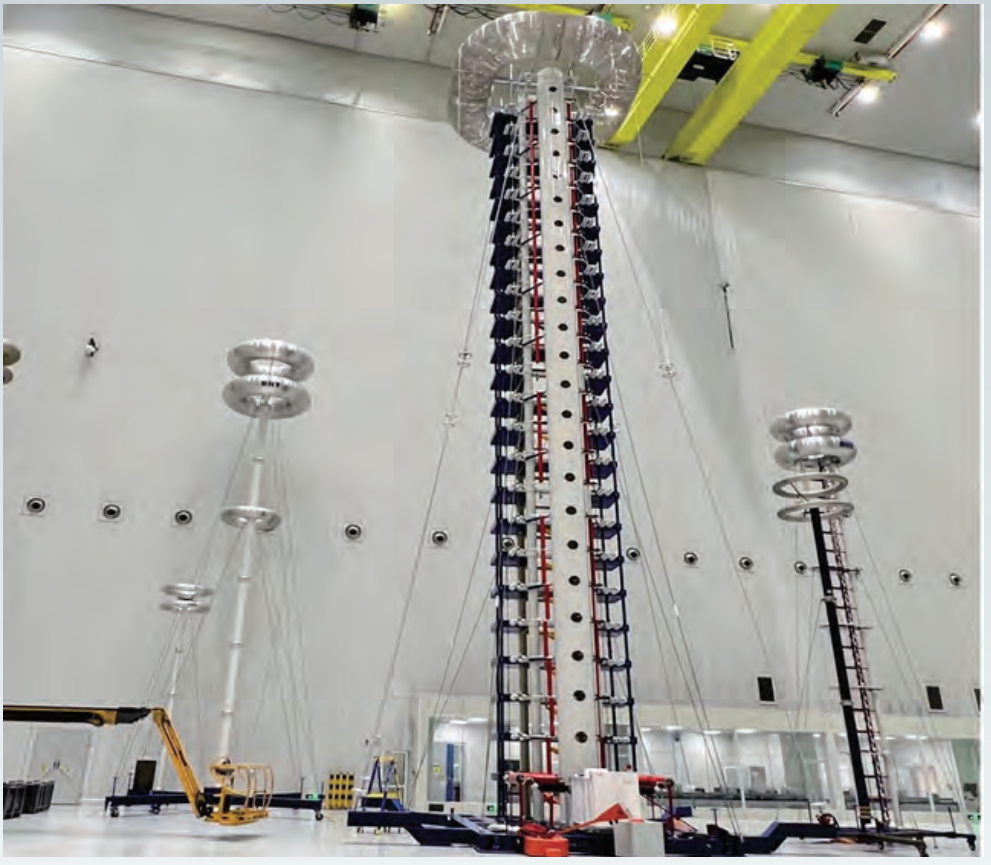
www.omtechnicalsolutions.com | *Follow us*

Mumbai | Vadodara |Rajasthan | Hyderabad | Chennai | Bangalore | Delhi | Kolkata | Raipur | Odisha | Jharkhand

BHT

PowerLine TransTech India 2025 EXHIBITION AND CONFERENCE
10 11 12 DECEMBER 2025
Yashobhoomi IICC Dwarka, New Delhi
Booth no. - B4

IMPULSE VOLTAGE GENERATOR



Suitable for impluse insulation withstand test of high-voltage electrical products such as transformers, switches, cables, reactors and insulators.

- **Unique synchronization technology, synchronization range ≥20%, synchronous failure rate ≤1%.**
- **The resistor is fitted with spring load connectors which enable fast and convenient installation and change of resistors.**
- **The generator is equipped with an internal ladder for human access of the stack. A folding work platform (electrically insulating) is installed at every third stack, so the operation and maintenance are safe and convenient.**
- **Standing lighting impulse with no load ≥90%; standard switching impulse (total load ≥3000 pF) ≥70%.**
- **Equipped with air cushion system (optional) for easy and smooth movement of equipment, which has been successfully operated on 6000kV impulse voltage generator.**
- **Capable of long-term operation at 80% of rated voltage:**
- **It can produce ≤6000 kV standard lightning impulse.**
- **It can produce ≤4200 kV lighting chopping impulse.**
- **It can produce ≤4800 kV AC switching impulse.**
- **It can produce ≥150% of oscillating impulse.**
- **It can produce special waveform with front time of 500 μs, 1000 μs and with ultra-long half peak time.**

MTek PRO TECHNOLOGIES PVT. LTD.

AUTHORIZED PARTNER

Mtekpro Technologies Pvt. Ltd.

28, 2ndFloor,OkhlaPhase-3,New Delhi - 110020

Email: info@mtekpro.com, taiyab@mtekpro.com | **Contact:** +91 11 35009275, +91 9810706882

www.mtekpro.com

Modular Intelligence

Unleash Power with Modular Intelligence.

The CPX 200 can be precisely configured to your needs, thanks to its modular hardware, software, accessories, and tailored service offerings.
You can begin with a flexible, multifunctional testing solution and later easily expand into a specialized testing system for your specific application needs.

Unlock the full potential with:
> 1000 A AC/DC with High Current Module
> 10 kV AC/DC with the system component HVX10
> Testing frequency range: 1-600Hz and DC
> and much more…

For those who empower.
CPX 200 is made for you.

RNI No.: 6226/1961