

Transformer industry undergoes evolution to meet capacity addition



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In partnership with Atlanture Transformer & Switchgear (P) Ltd



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The projected increase of over 433,000 MVA in substation capacity nationwide has served as a guiding force for the transformer sector. Amit Varshney shares his expertise in talks with EPR.

How are modern power transformers being designed to handle increased load and bidirectional power flows from renewable energy integration?

Modern transformers are undergoing

fundamental design evolution to accommodate India's renewable energy targets. We are implementing advanced core designs with optimised flux distribution to handle variable loading patterns typical of solar and wind generation. The key innovation lies in on-load tap changers (OLTC) with wider voltage regulation ranges—typically $\pm 15\%$ to $\pm 20\%$ —enabling dynamic voltage control as renewable generation fluctuates throughout the day.

Bidirectional power flow capability requires enhanced thermal management since reverse power flow creates different hot-spot temperatures. We are utilising computational fluid dynamics to optimise cooling systems and ensure that the transformer's lifespan is not compromised. Additionally, we are designing for higher short-circuit withstand capability, as integration points for renewables can experience sudden fault currents. At Atlanture, we have incorporated amorphous metal cores into select designs, reducing no-load losses by up to 70 percent, which is crucial when transformers operate at partial load during off-peak periods of renewable generation.

What role do digital and intelligent transformers play in smart substations?

Digital transformers represent a paradigm shift in asset management. These units integrate sensors, communication modules, and edge computing capabilities directly into the transformer tank. Real-time monitoring of critical parameters—oil temperature, winding temperature, moisture content, partial discharge activity, and bushing health—enables predictive maintenance strategies that reduce unplanned outages by 40-50 percent.

Intelligent transformers equipped with IEC 61850 communication protocols seamlessly integrate with substation automation systems, enabling centralised condition monitoring.

The fault detection capabilities are particularly transformative. Our systems can identify incipient faults months before catastrophic failure through pattern recognition algorithms analysing dissolved gas concentrations and thermal signatures. This shifts maintenance from time-based to condition-based, optimising both reliability and lifecycle costs. For utilities managing hundreds of transformers across vast geographical areas, this centralised intelligence is invaluable for resource allocation and grid stability.

How are manufacturers addressing the surge toward 433,000 MVA of substation capacity addition by 2030?

Meeting this ambitious target requires manufacturing excellence across efficiency, safety, and lifecycle performance. We are investing in advanced testing facilities, including partial-discharge measurement systems, frequency-response analysis equipment, and acoustic-emission monitoring, to ensure every transformer meets stringent quality standards.

Efficiency improvements focus on ultra-low loss designs, utilising grain-oriented silicon steel with losses below 0.9 W/kg and optimised winding configurations to minimise stray losses. Safety enhancements include advanced fire-resistant insulation fluids, pressure relief devices with rapid response times, and comprehensive Buchholz relay protection.

Lifecycle performance is addressed through corrosion-resistant tank coatings, hermetically sealed conservator systems to prevent moisture ingress, and modular designs facilitating easier maintenance. Atlanture has established dedicated production lines with capacity-expansion roadmaps aligned with sectoral demand, ensuring we contribute meaningfully to India's infrastructure goals while maintaining uncompromising quality standards.

How are advanced monitoring systems improving transformer health management?

The adoption of dissolved gas analysis (DGA), fibre-optic temperature sensors, and IoT-based diagnostics represents a technological revolution in asset management. Online DGA systems continuously monitor gas concentrations of hydrogen, methane, ethylene, and acetylene, providing early warning of thermal or electrical faults. This continuous monitoring detects issues 6-12 months earlier than traditional quarterly oil sampling.

Fibre-optic sensors placed directly on hot spots in the winding provide accurate, real-time temperature data immune to electromagnetic interference, enabling precise thermal modelling and dynamic loading decisions. IoT integration allows utilities to aggregate data from thousands of transformers into centralised analytics platforms, applying machine learning algorithms to identify anomalous patterns and predict failures.

We are seeing utilities reduce catastrophic failures by 60 percent and extend transformer life by 15-20 percent through these proactive strategies. The economic case is compelling, preventing a single 220 kV transformer failure typically saves ₹3-5 crores in replacement costs and avoided outage penalties.

What innovations are emerging for higher voltage and inter-regional transmission?

The transition to 765 kV and the future 1200 kV transmission systems require breakthrough materials and designs. Advanced insulation materials, including aramid paper with superior thermal stability and nanocomposite fluids with enhanced dielectric strength, are enabling more compact, reliable designs.

Cooling innovations include hybrid systems combining oil-natural air-forced (ONAF) with directed oil flow, achieving 30 percent better thermal performance. We are exploring ester-based insulating



fluids offering biodegradability, higher fire points, and extended asset life.

Environmental performance improvements include SF6-free bushings, recyclable core materials, and designs minimising oil volumes. These innovations ensure India's transmission infrastructure meets both technical requirements and environmental sustainability commitments, positioning our grid for reliable operation through 2050 and beyond.

MECO unveils DIT 945PI, a versatile digital insulation tester

Built with multi-range selection options of 250V, 500V, 1000V, and 2500V, it supports insulation resistance measurements up to an impressive 200GΩ.



Meco introduced its latest device DIT 945PI. The MECO DIT 945PI is a robust and versatile 2.5kV digital insulation tester designed for high-precision electrical testing across industrial and utility applications. Built with multi-range selection options of 250V, 500V, 1000V, and 2500V, it supports insulation resistance measurements up to an impressive 200GΩ, making it suitable for evaluating the health and reliability of transformers, motors, generators,

high-voltage systems, and power cables. Its capability to measure low resistance up to 60Ω and AC voltage up to 600V further enhances its utility as a comprehensive diagnostic tool.

Featuring a 4-digit (2000 counts) large LCD display with backlight, the DIT 945PI ensures clear visibility even in low-light conditions. The tester integrates advanced diagnostic functions such as Polarisation Index (P.I.) and Dielectric Absorption Ratio (D.A.R.), which provide deeper insights into insulation quality over time, critical for preventive maintenance and asset management in electrical systems. The auto-range insulation test, single-person push-button operation, and data hold feature improve ease of use, while an over-

range alarm and high-voltage indication ensure safe operation.

Engineered for demanding field environments, the device comes with a shock, dust, and moisture-resistant casing, complemented by a heavy-duty rubber holster for added durability. It adheres to IEC/EN 61010-1 safety standards and is rated CAT II 1000V and CAT III 600V, ensuring reliable protection during testing tasks. Operable on battery or 12V DC, the MECO DIT 945PI delivers accuracy, safety, and rugged performance, making it an ideal choice for professionals engaged in electrical maintenance, testing, and troubleshooting.

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