Electrical manufacturers retool for bidirectional grids and digital substations

The industry is scaling up production of smart inverters, hybrid transformers, and advanced protection systems to address the intermittent nature of renewable energy

The electrical equipment industry is undergoing a remarkable transition to align with renewable energy integration and digital advancement.

Manufacturers adapting to support bidirectional power flows

Manufacturing facilities are fundamentally retooling to produce equipment compatible with bidirectional power flows, a critical shift from traditional unidirectional grids. The industry is scaling up production of smart inverters, hybrid transformers, and advanced protection systems that address the intermittent nature of renewable energy. Battery energy storage systems have transitioned from custom solutions to standardised products. This has enabled mass production and cost reduction. Supply chain localisation under 'Make in India' has accelerated domestic capacity while reducing import dependency, creating infrastructure suited to India's specific grid requirements and climatic conditions.

Digital substations transforming engineering design priorities

Digital substations represent a paradigm shift that I have closely observed through my engineering consultancy work. Design priorities have evolved from purely electrical considerations to a holistic cyber-physical approach. Communication architecture using the IEC 61850 protocol is now as critical as electrical architecture. Physical footprint optimisation through fibre-optic networks replaces extensive copper wiring, saving crucial space in urban installations while improving reliability.

From my project management experience, design now prioritises system integration testing over individual equipment testing. Cybersecurity has become foundational rather than an afterthought, with network segmentation and encryption integral to specifications. The industry is creating future-proof designs with spare processing capacity to accommodate emerging applications like predictive maintenance and advanced grid analytics.

Traditionally passive electrical assets to intelligent systems

One of the most exciting developments is transforming traditionally passive assets into intelligent devices. Manufacturers are embedding IoT-enabled sensors into components that were historically 'dumb.' Modern circuit breakers now feature temperature sensors, vibration monitors, and operational counters that transmit real-time health status. Transformers incorporate dissolved gas analysis sensors and thermal imaging capabilities.

Miniaturisation of sensors and edge computing, combined with low-power wireless technologies such as LoRaWAN, enable even remotely located assets to communicate data economically. From my automation experience, I have seen manufacturers offer retrofit solutions for legacy equipment that extend their useful life while adding monitoring capabilities. The real value emerges when asset-level data integrates with enterprise systems to support predictive maintenance and evidence-based investment decisions.

Transmission corridors optimised to increase capacity

Corridor utilisation without physical expansion addresses India's critical infrastructure challenges. High-temperature, low-sag conductors and HVDC technology allow 50-100 per cent capacity increases using existing rights-of-way, avoiding lengthy land acquisition. Dynamic line rating systems optimise asset utilisation by adjusting capacity in response to real-time conditions, transforming static systems into adaptive ones.

However, challenges exist. Protection systems must handle increased fault currents, and regulatory frameworks often lag technological capabilities. Asset ageing requires sophisticated condition monitoring, particularly when maximising utilisation of infrastructure approaching design life. Coordinating multiple stakeholders becomes more complex when optimising existing corridors rather than building new ones.

Through meticulous pre-planning and analysis, principles central to our consultancy approach, these challenges can be systematically addressed. The industry's evolution represents an exciting convergence of renewable integration, digitalisation and intelligent infrastructure optimisation, which creates sustainable solutions that meet India's growing energy demands while maximising existing resources.

Authored by:
Amit Varshney
Director, RM Controls (P) Ltd | CEO, VR Engineering and Consultancy Services I President, Atlanture Transformer & Switchgear (P) Ltd