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Advanced Sensor Technology

Dave Meyers on how a small sensor can save power systems from massive failure.

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When dealing with critical infrastructure such as electric power systems, waiting until a crisis occurs can be costly and dangerous. Power networks form the backbone of modern economies by keeping hospitals running, trains moving, and industries operating. But too often, investment in maintenance comes only after a fault has already caused major disruption, leading not only to financial losses but also to risks to public safety and a gradual erosion of trust in the essential services that keep societies functioning.

A fire at a substation near Heathrow Airport in February illustrated this reality all too vividly. A single transformer fault cascaded into a blackout that left more than 66,000 homes without power, grounded over 1,300 flights, and caused losses estimated at more than £100 million.

Investigations suggested that elevated moisture and insulation deterioration had been detected in the equipment years earlier, but warning signs went unaddressed. What could have been a manageable maintenance task instead became a national incident.

A global challenge

Failures in transformer monitoring can be catastrophic. Across the world, power grids are under mounting pressure from aging equipment, rising demand, and the push toward electrification. Transformers carry heavier and often bi-directional loads for longer periods, frequently with minimal oversight.

Nearly 40% of the UK's transmission equipment predates 1975, and like many other places in the world, the wait for replacements is neither quick nor easy. In many markets, domestic production capacity is limited, creating a dangerous mismatch between supply, demand, and maintenance capability. As the world accelerates towards greater electrification, this strain will only intensify. Electricity demand in the UK alone is expected to rise by 30% by 2030.

Across the globe, electrification of transport, data centres, and industry is adding layers of complexity to already fragile systems. This growing stress on aging infrastructure is creating serious vulnerabilities that cannot be solved by replacements easily given today's supply chain challenges. Utilities and regulators must therefore turn to smarter, more affordable solutions that can prevent failures before they occur.

Hydrogen as an early warning sign

Hydrogen monitoring of transformers is one such solution. When a transformer begins to deteriorate, hydrogen gas is among the earliest warning signs of internal failures. It forms when the insulating oil inside the transformers breaks down due to overheating or internal electrical arcing caused by faults, mechanical defects or insulation breakdown.

Historically, operators relied on the analysis of manual oil samples taken from transformers every one to four years. While useful, this approach leaves long blind spots as faults can develop and escalate between inspections, often without warning. By the time results are known, the damage may already be done.

Modern hydrogen sensors have transformed this equation. Compact, affordable, and maintenance-free, they can be mounted directly on transformers to provide continuous, real-time monitoring. They alert operators the moment hydrogen levels rise, enabling preventive action before minor faults escalate into catastrophic failures. These sensors cost a fraction of the losses associated with a major outage like Heathrow's, yet their value to system reliability is immeasurable.

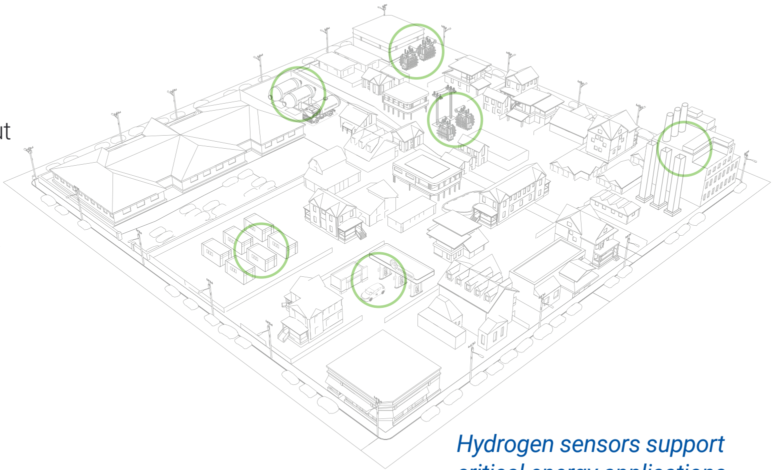
Real-time monitoring also allows operators to shift from reactive to predictive maintenance. Instead of responding to crises, utilities can schedule repairs, adjust loads, or plan replacements on their own terms. This proactive approach reduces emergency callouts, enhances worker safety, and can extend transformer lifespan by up to 20%. In a world where replacement lead times stretch into years, those additional years of service can be invaluable. Moreover, by avoiding forced outages, utilities maintain continuity of service for hospitals, airports, data centres, and communities, which cannot afford even brief interruptions.

The benefits of real-time hydrogen monitoring extend beyond safety and reliability to strengthening the financial foundation of utilities. Studies have shown that predictive maintenance enabled by condition monitoring can reduce maintenance costs by up to 25%, largely by minimising emergency repairs and optimising asset management. In practical terms, every avoided outage translates into millions saved, and a significant reduction in lost productivity and reputational damage.

Critics sometimes argue that continuous monitoring adds cost or operational complexity. In fact, it does the opposite. These sensors detect hydrogen in concentrations as low as parts per million, giving engineers an early window into the health of their assets. They eliminate the logistical and environmental costs associated with manual sampling, travel, and lab testing. Installation can often be completed in hours without taking the transformer off-line. The data is transmitted digitally, allowing remote diagnostics and automated alerts. In many cases, the return on investment is achieved within the first few years of operation.

Technical ability and transparency

The Heathrow fire underscored the importance of visibility and accountability. Reports indicated that key maintenance actions were delayed or overlooked, partly because condition data was fragmented or unavailable in real time. Hydrogen monitoring,



Hydrogen sensors support critical energy applications

conversely, has the technical ability to detect faults and the transparency to ensure that warnings are acted upon promptly. For utilities and regulators, this visibility strengthens governance and provides a factual basis for decisions that affect grid safety.

For developing economies, the value proposition is even clearer. In regions such as Africa, South Asia, and parts of Latin America where budgets are constrained and the pace of demand growth is fastest, hydrogen sensors represent a cost effective safeguard. Extending the life of existing transformers while avoiding major blackouts can make the difference between sustainable growth and costly disruption. Rather than waiting for grid modernisation programs that may take decades, utilities can deploy these sensors today to build resilience immediately.

At a broader level, hydrogen monitoring also supports global decarbonisation goals. As renewable energy integration increases, grid volatility grows. Solar and wind generation introduce variability that traditional grids were not designed to handle. By providing operators with continuous insight into asset health, hydrogen monitoring helps maintain reliability even as renewable penetration rises. In this way, it directly supports the clean energy transition, ensuring that the move to a low-carbon future is not undermined by preventable infrastructure failures.

Ultimately, a small sensor can prevent a very big problem. The Heathrow blackout began with a single transformer fault that could likely have been detected in advance. The technology to prevent such incidents exists, it is affordable, proven, and available.

What is needed now is urgency and commitment from utilities, regulators, and policymakers to make real-time monitoring a universal standard rather than a selective upgrade.

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