Reprinted From
Enlit
December 2025

Early detection of transformer faults is critical to grid stability

Although engineered for reliability, transformers are not immune to degrading.

H2Scan's André Marais writes on how ageing transformers are emerging as one of the most underestimated risks to grid reliability and how hydrogen gas release is the earliest signal of this breakdown, marking it a key warning sign before the damage becomes irreparable.

André Marais

As electricity demand accelerates, faulty or ageing transformers are emerging as one of the most underestimated risks to grid reliability. That risk was made clear earlier this year when a transformer fault at a substation near London's Heathrow International Airport triggered a fire that cascaded into a blackout affecting tens of thousands of homes, grounding more than a thousand flights, and causing nearly £100 million ($133.2 million) in damages. But the Heathrow incident was not an isolated event. It was the third transformer-related fire in the UK within a single month and one of eight such incidents reported over ten weeks.

Hydrogen gas is the earliest signal of breakdown

Transformers are engineered for reliability, with wire coils wound around a steel core and often immersed in oil for cooling and insulation. But they are not immune to degradation. Over time, heat, electrical stress, and moisture ingress weaken insulation. The effect is gradual but damaging. Hydrogen gas release is the earliest signal of this breakdown, making it a valuable warning sign before the damage becomes irreparable.

Traditionally, utilities have relied on dissolved gas analysis, sending oil samples to laboratories once every one to four years. While useful, this method only provides a snapshot of transformer health. It has been shown that most faults develop from first gassing to complete failure in six months, so annual laboratory analysis can leave equipment vulnerable. In today's high-demand environment, that uncertainty is becoming increasingly untenable.

Hydrogen sensors are emerging as a practical method for detecting developing (incipient) transformer faults in real-time. Compact, affordable, and maintenance-free, they can be installed directly on transformers within a matter of hours to continuously track hydrogen concentrations. Operators are alerted the moment levels rise, allowing them to intervene before minor issues escalate into full failures. At only a few thousand dollars per unit, the cost is small compared to the economic damage of a consequential outage, such as Heathrow's.

> ***Even the most extensive blackouts can begin with a single point of failure.***
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> *– André Marais, Executive Vice President, H2Scan*

Continuous monitoring also enables a shift from reactive to predictive maintenance. Early detection allows utilities to schedule repairs, adjust loads, or plan replacements on their own terms. This reduces the need for emergency interventions, improves worker safety, and can extend transformer life by up to 20%. With replacement lead times extending into years, lifecycle extension provides a highly effective way to extend the lifecycle with limited infrastructure investment.

Extending service life

The benefits extend beyond asset management. Even the most extensive blackouts can begin with a single point of failure. With real-time monitoring, early signs of insulation breakdown or overheating can be identified and addressed before they escalate into wider disruptions. For critical facilities such as airports, hospitals, and data centres, that resilience is indispensable.

In emerging markets, the case is even stronger. Utilities in regions such as Africa face rapidly rising demand but often lack the capital to replace equipment at scale. Deploying hydrogen monitoring across transformer fleets allows them to extend the service life of existing assets while avoiding blackouts that could undermine economic development.

The Heathrow fire may have been the most visible incident, but it was far from unique. The stark reality is that fires leading to blackouts have a profound impact on lives, livelihoods, and economies. Pew Research estimates that power interruptions cost US businesses approximately $150 billion annually due to unproductive downtime, damaged equipment, spoiled products, lost data, and disrupted services. These risks remain as long as ageing equipment operates under growing demand without adequate monitoring.

Equipping operators with real-time insight into transformer health is a practical and cost-effective step toward reversing this trajectory. By adopting hydrogen-based transformer monitoring, utilities will improve their customer satisfaction and energy delivery metrics (CML or SAIDI), extend the lifespan of their critical assets, and increase the reliability of their grid upon which modern economies depend.

About the author:

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