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Transformer Monitoring for Wind Energy

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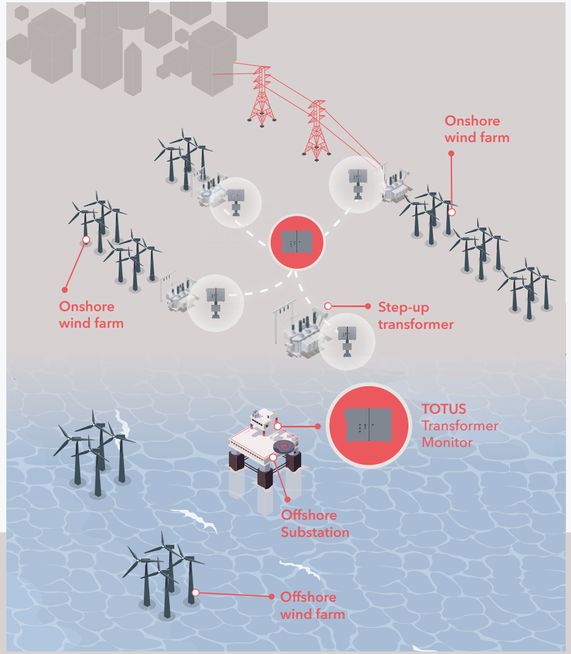
Introduction to the wind energy sector

Central to the success of wind energy projects is the reliable operation of assets, ensuring consistent availability and uptime. With the continued growth of wind energy production across the UK, maintaining optimal performance becomes even more crucial for wind farm managers and operators.

The role of transformers in wind farms

Transformers are a crucial part of wind farm infrastructure; they facilitate the conversion and transmission of power generated by wind turbines.

Transformers can be a single point of failure when connecting wind farms to the energy network. And although they are static assets with a relatively simple working principle, they are complex mechanically, made up of several materials, such as copper, iron, solid and liquid insulating materials like paper, wood, porcelain, resin, and oil. If these transformers suffer a critical failure due to an undetected fault, this can result in costly downtime.



What happens when a transformer fails?

When it comes to critical assets, transformers are at the top of the list and when they fail prematurely, it can be increasingly problematic. The financial impact can far exceed the cost of damage to the transformer with revenue loss, contractual penalties and additional insurance costs having to be considered.

A transformer on a wind farm often operates in an environment unlike its utility counterparts and is subject to its own unique stresses. If the damage is severe enough, a total transformer replacement or refurbishment could be required. On average a replacement transformer can take up to 18 months to procure, deliver and install, costing an offshore wind farm operator up to £22 million (based on most conservative estimate of replacement).

Project size	100 MW
Average loading rate	35%
Electricity price	£50/MWhr
Lead time for replacement transformer	18 months
Revenue loss	**£22 million**

Depending on the wind farm's installation type, particularly offshore wind farms, transformer repair and/or replacement can be even more challenging due to weather conditions and transport logistics - greatly increasing the length of downtime and cost of repair to the transformer.

The Challenges:

Why do transformers fail?

While transformers are intended to have a lifetime that exceeds the life of your project, they can and do fail for several reasons:

Variable load patterns

Wind-induced acceleration below the generator's cut-off speed can lead to harmful thermal cycling and degradation in transformer components, ultimately requiring maintenance such as oil replenishment.

Higher loading targets

The current political and economic landscape emphasises the importance of low-carbon energy sources in the UK's competitive energy market, putting pressure on transformers to handle higher loads for increased electricity production.

Environmental factors

Transformers face increased voltage transients from wind gusts, lightning strikes, and swells, inducing vibrations that impose mechanical stresses, potentially causing severe damage. Additionally, exposure to saline air for coastal and offshore installations and ultraviolet radiation accelerates corrosion of gaskets and seals, compromising the preservation system.

Through fault current

External events, especially faults accounting for over 20% of failures, pose the primary risk for transformer failures in wind generation; transformers in this context must possess Fault Ride Through Capability, in order to endure more stressful fault conditions than regular substation transformers.

Additionally, the intermittent nature of wind power introduces challenges related to voltage fluctuations and grid instability, placing further strain on transformers.

The solution:

Investing in a transformer monitoring program

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With over 20 years of experience in delivering end-to-end transformer monitoring solutions, we have established ourselves as a proven and reliable partner for wind energy providers.

The role of transformer monitoring

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Transformer monitoring aims to pre-emptively detect and address potential issues before they escalate into costly failures. Traditionally, transformers have monitored through periodic inspections and manual assessments. However, advancements in technology have ushered in a new era of predictive maintenance, where monitors, data analytics, and machine learning algorithms work in tandem to provide real-time insights into the health and performance of these essential assets.

Recognising the critical role transformers play in the wind energy ecosystem, Kelvatek offers an end-to-end solution designed to safeguard these vital assets. Comprising of the TOTUS transformer monitor, software that visualises and communicates the condition of your assets, as well as a variety of expert services. These components work together as one unified system to produce actionable insights for asset managers, providing a comprehensive approach to transformer monitoring.

Monitor

Software

Services

Benefits

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Cost savings

- Reduced operations and maintenance costs: Effective monitoring and pre-emptive maintenance prevents costly transformer damage, reducing repair or replacement expenses ensuring significant ROI for your wind project.
- Protected revenue: Proactive maintenance ensures continuity of operations, averting revenue losses during prolonged periods of downtime.
- Optimised resource allocation: By mitigating financial risks associated with transformer failures, businesses can allocate resources more efficiently towards growth and innovation initiatives.
- Reduced insurance premiums: Implementing a monitoring solution provides better information on the health of the asset being insured. It enables preventative maintenance to be undertaken before faults develop to a point of catastrophic failure, therefore reducing the risk to insurers.

Operational efficiency

- Streamlined emergency response: Avoid logistical nightmares by proactively addressing issues, eliminating the need for emergency repairs, minimising downtime.
- Business continuity: Sustain operations without disruption, safeguarding productivity, and reputation.

Energy supply reliability

- Enhanced grid stability: Preventing transformer failures maintains a consistent energy flow, enhancing the stability and reliability of the energy network.
- Maintain production efficiency: Uninterrupted energy supply enables businesses to maintain production schedules, ensuring timely delivery of goods and services to consumers.

Maximised safety

- Online monitoring: Reduce unknown and unseen risk with knowledge to safely operate the grid, while minimising time spent on site.

TOTUS Transformer Monitoring (Monitor)

Providing a DGA profile of 9 gases, Kelvatek's TOTUS transformer monitor presents a proven solution tailored for wind energy providers, offering precise identification and detailed breakdown of transformer faults.

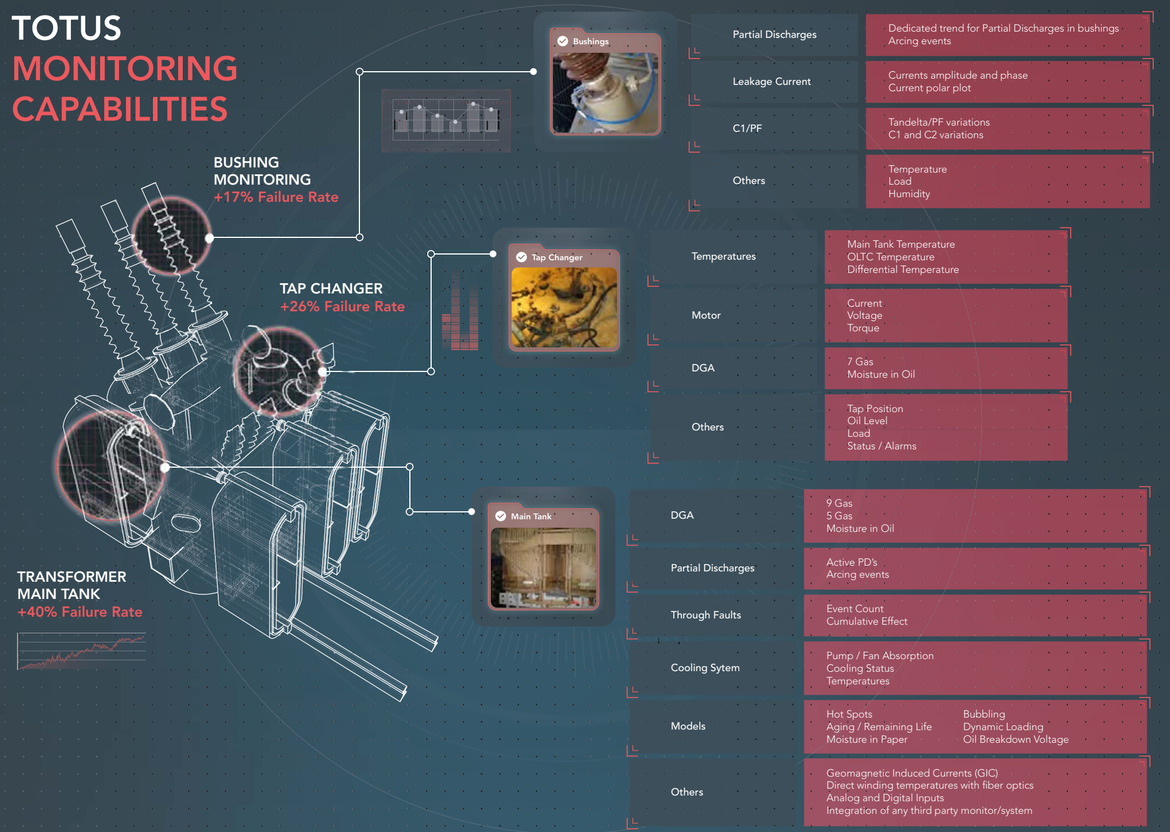
Engineered to optimise operational efficiency and streamline maintenance budgets, TOTUS empowers asset managers to implement comprehensive asset monitoring strategies across diverse transformer types and sizes.

Analysing crucial gases and moisture in oil, this system integrates web-based analytics to furnish detailed asset insights into transformer health via intuitive, customisable dashboards. By displaying these insights online, asset managers can monitor their transformer fleet remotely, reducing costly visits to site and enabling 24/7 visibility.

TOTUS offers real-time assessment of transformer condition, empowering asset managers to swiftly respond to potential failure risks, taking them from an environment of reactive maintenance to predictive.

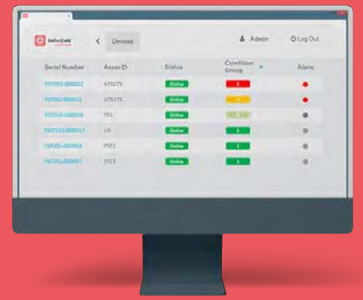
Key features

- Enhanced risk management: Identifies all basic transformer faults, reducing the risk of unexpected failures.
- Seamless Integration: Simple installation without the need for additional software or transformer downtime.
- Cost-efficient: No ongoing expenses for calibration or carrier gases, leading to lower overall costs.
- User-friendly interface: Intuitive interface requires no external software, providing enhanced usability.
- Comprehensive monitoring: Scalable options include additional modules for Partial Discharge, Bushing Monitoring, and Through Fault Currents, providing a holistic view of transformer health.
- Modular design: Built-in modules cater to various monitoring needs, ensuring adaptability and flexibility.



Software

Software is a vital component of our end-to-end offering. Our customisable software suite is designed to maximise efficiency, reliability, and profitability for your wind farm operations. With multiple options available depending on the size and scale of your project, we ensure you have a tailored solution to suit your project's needs.



The TOTUSPRO ACCESS module immediately highlights which transformers are the greatest risk, and sends email notifications, allowing Asset Managers to make decisions across the entire transformer fleet.

Software

TOTUSPRO ACCESS

TOTUSPRO Access streamlines online device management, offering simplified login, user management and alarm management. It integrates data from TOTUS transformer monitors, aiding Asset Managers in translating diagnostic information from both offline and online sources into preventative actions. Giving a clear view of asset and fleet health, TOTUSPRO helps reduce unplanned transformer shutdowns and increase operational efficiency.

Software

Sapient™ | Asset Insights

Sapient Asset Insights is an asset performance management solution which elevates the reliability and performance of your transformer fleet.

By integrating various data sources and leveraging sophisticated engineering analysis techniques along with AI/ML analytics, our software has the capability to convert raw data into valuable insights and predict the performance of transformers.

These insights are not only actionable but are also seamlessly integrated across an entire transformer portfolio, enhancing wind companies' planning and asset management workflows. With Sapient Asset Insights, users can make informed decisions based on real-time data, leading to optimised asset performance, and increased operational efficiency.

Sapient Asset Insights:

Application Features

Data Aggregation

Data aggregation is a crucial component in asset management solutions as it consolidates accurate and complete data from various sources. By seamlessly integrating data from real-time online monitoring and historical offline test data, organisations can make informed decisions regarding their assets.

Work Management

Work management plays a vital role in maintaining critical assets by integrating with existing systems and processes to support end-to-end work processes. This integration enables organisations to initiate, track, and manage required actions efficiently.

Predictive Analytics

Sapient Asset Insights leverages data from multiple sources and harnesses machine learning to predict future asset performance. By analysing data patterns, anomalies, and trends, predictive analytics can help identify potential issues before they occur, allowing for proactive maintenance.

Prescriptive Actions

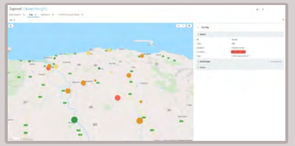
Moreover, when faced with extensive data analysis, Sapient Asset Insights provides prescriptive actions based on asset health to automate and prioritise maintenance activities. This approach helps organisations streamline their maintenance and lifecycle planning activities by defining precise action plans.

Decision Support

A decision support framework enhances asset management by visualizing assets and key performance indicators (KPIs). These visual representations cater to different application needs and facilitate decision-making processes.

Impact of Failure

Additionally, users can configure asset criticality and assess the impact and costs of failure by combining probability of failure with asset classes. This user-defined approach allows organisations to proactively address potential risks and optimise asset management strategies.



Asset health

We combine our deep domain knowledge and engineering expertise to create asset-specific models that can accurately assess the health of assets. By utilising sophisticated algorithms and data analysis techniques, these models can calculate and establish health score indexes that provide valuable insights into the condition of assets. This information enables organisations to make informed decisions, optimising operational efficiency and minimising downtime.

Software

The value of Sapient Asset Insights

Sapient Asset Insights enables operators to shift from reactive to predictive maintenance strategies minimising the risk of catastrophic failures while and improving overall operational efficiency. Additionally, by leveraging the power of data and analytics, organisations can make more informed decisions, ensuring resources are allocated effectively.

Optimised capital expenditure

Extending asset lifespan is vital for capital optimisation, Sapient Asset Insights enables wind farms to manage current risks (spend less) or spend the same amount and achieve higher reliability through replacing the riskiest assets.

Optimised O&M budgets

Operating expenses are reduced by optimising preventive-maintenance (PM) activities, leveraging condition-based maintenance practices.

Improved data management

Enhanced operational efficiency with a consolidated view of asset data from multiple sources, eliminating data inaccuracies and loss of knowledge.

Reduced risk of catastrophic failure

Sapient Asset Insights assesses failure risks, enabling asset managers to prioritise replacing critical assets to increase system reliability, measured by SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) metrics. Focusing on high-risk assets enhances overall system reliability, minimising catastrophic failure chances.

Actionable insights for faster decision making

Predictive analytics provide actionable analysis and recommendations to drive quicker and more accurate decision making.

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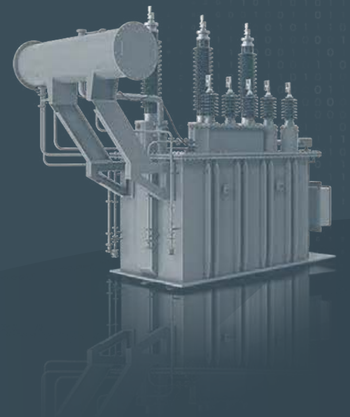
Sapient Asset Insights and transformers

The transformer analytics module of Sapient Asset Insights processes online monitoring and laboratory test data to provide;

- Anomaly detection
- The calculation of a condition index
- Failure modes
- Set of prescriptive actions for each transformer within the fleet

Individual condition indices are provided for each part of the transformer (main tank, bushing, tap changer and cooling) along with detailed failure modes and maintenance actions.

The module implements proprietary and industry-standard algorithms embedding Kelvatek's expert knowledge to analyse the data from the most informative diagnostic tests like DGA (Dissolved Gas Analysis), oil quality tests, electrical tests, partial discharge data.



Service:

Expert services

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Kelvatek is more than just a provider of hardware and software; we are your dedicated partner in navigating the challenges of the evolving wind energy industry. With a deep understanding of the sector's challenges, we recognise the pressures faced by asset managers to optimise performance amidst harsh environmental conditions. Our suite of expert services goes beyond mere product provision, offering invaluable expertise, support, and ongoing training to ensure our clients extract maximum value from their monitoring technology investments.

Our customers benefit directly from our unique expert knowledge on transformers and monitoring solutions. The Kelvatek approach covers three key areas: expert services, condition assessment and field service & customer delivery.

Expert services

Kelvatek offers an array of expert services, providing our customers with direct access to our extensive knowledge base on transformers and monitoring solutions. Our in-house team of experts boasts a wealth of experience, enabling us to offer comprehensive support in three key areas: product training, expert support, and academic seminars.

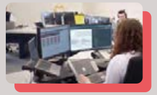
Field service & customer delivery

From product conception to installation and ongoing support, Kelvatek is with you every step of the way. Our field service and customer delivery programs encompass dedicated account management for installation, commissioning, and aftercare. Along with a bespoke customer support portal and round the clock assistance. With Kelvatek as your partner, you can navigate the complexities of the wind energy industry with confidence, knowing expert support is always at your fingertips.

Training

Our product training sessions provide a clear understanding of the working principles of your monitoring system, its hardware operation, and the handling of accompanying software. Furthermore, dedicated training enables customers to install and commission the system on their own, providing cost reduction and flexibility. We provide in-depth training on the following areas;

- Principles & Operation: Principles & Operation training provides insights on the product methodology, its working principles and useful information on how to operate the system software.
- Installation & Commissioning: This practical course provides the necessary knowledge on how to install & commission your transformer monitoring systems. The training applies in particular to those customers who prefer to manage their own installations.



Condition assessment

Our Condition Assessment Service integrates online monitoring data with on-site inspections, lab analysis, and other offline information. By providing a holistic view of asset health, we equip our clients with actionable insights to mitigate the risk of transformer failure. Unlike other monitoring systems that offer data trending and alarm notifications, TOTUS stands out for its ability to visually represent transformer condition at a glance. Our condition assessment service includes asset reporting, acceptance tests, and online tests, ensuring comprehensive evaluation and proactive maintenance planning.

Safeguarding commercial success

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Implementing transformer monitoring systems is not just about ensuring operational efficiency; it's about safeguarding commercial success. Transformer failures can lead to catastrophic consequences, including costly downtime and significant financial losses. Kelvatek's end-to-end solutions provide a proactive approach to mitigating risks to asset availability by offering real-time insights into the health of your transformer fleet. By identifying developing faults before they escalate into failures, monitoring systems help prevent revenue loss and other associated charges including:

- Contractual penalties for failure to supply
- Cost of repair or replacement of the failed transformer
- Additional insurance premiums
- Safety impacts

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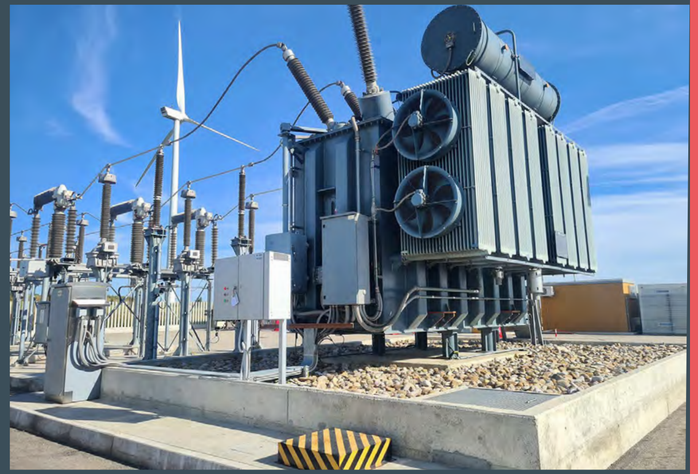
For over two decades, Kelvatek has been working collaboratively across the UK & Ireland energy industry to accelerate network performance and drive a more sustainable future. Partnering with world-leading wind farms, energy utilities and data centre operators, Kelvatek provides industry-leading transformer monitoring solutions and services.

We help the operators of these facilities gain a deeper understanding of the risk, health, and performance of their transformer fleet through our secure, robust, and accurate online monitoring solutions. By monitoring the most critical components of a transformer, our solutions deliver actionable insights which optimise proactive maintenance strategies, improve availability and uptime of assets, and significantly reduce the risk of sudden transformer failure, associated costs and lost revenues.



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