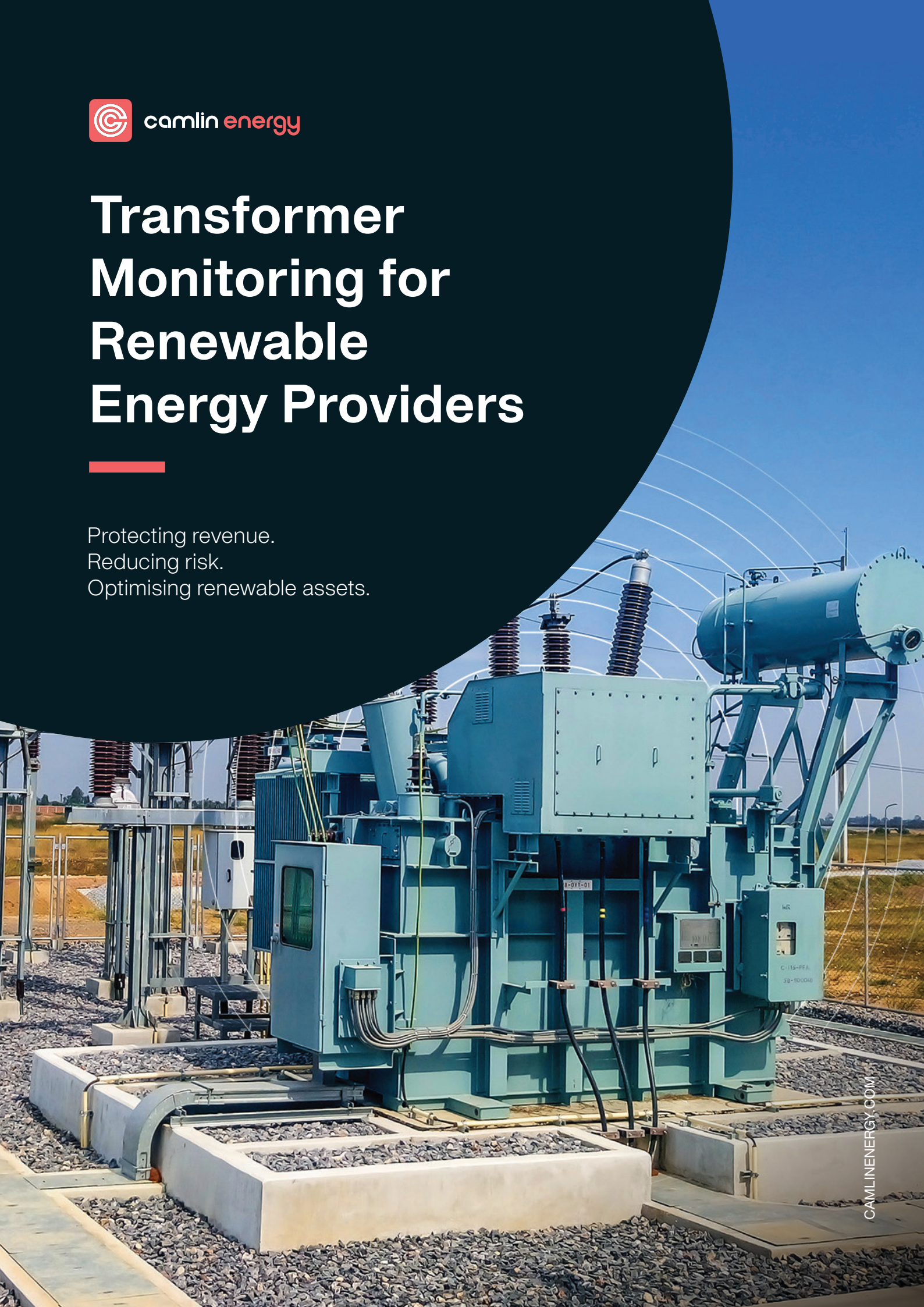
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Transformer Monitoring for Renewable Energy Providers

Protecting revenue.
Reducing risk.
Optimising renewable assets.



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Safeguarding your connection, protecting your revenues

Transformer monitoring is essential for renewable energy providers, as the transformer represents a single, highly critical asset that safeguards the grid connection and enables revenue generation. Failure of this asset can result in prolonged outages, costly replacements, and significant loss of income from renewable energy generation.

Continuous monitoring provides early warning of developing faults, thermal stress, and abnormal loading caused by variable renewable generation, allowing issues to be addressed before they escalate into catastrophic failures. Beyond improving reliability and extending asset life, robust monitoring can also deliver tangible financial benefits, including reduced insurance premiums by demonstrably lowering risk and improving asset management practices. In the context of the global energy transition, transformer monitoring is not only a technical necessity but a strategic investment to protect revenues, strengthen insurability, and ensure long-term operational resilience.

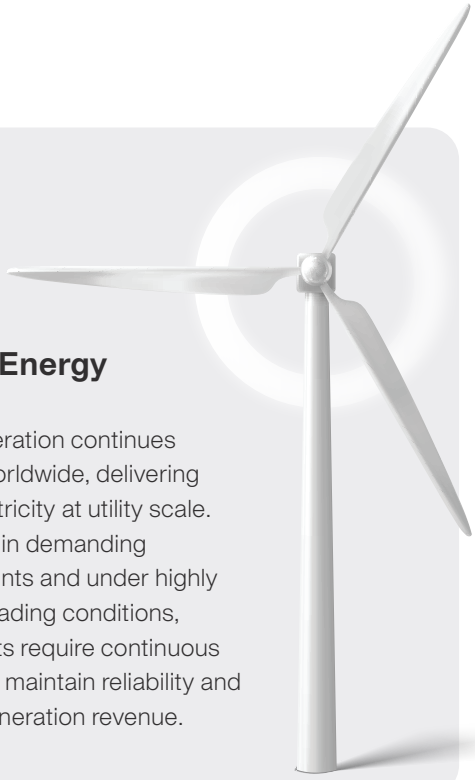


Powering the transition to a more resilient energy future.

The global energy landscape is evolving rapidly. Wind, solar, battery energy storage systems (BESS) and data centres are driving unprecedented demand for reliable electrical infrastructure, while supporting the transition to a cleaner, more connected and increasingly electrified future.

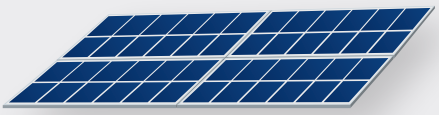
As these sectors continue to grow, operators face increasing pressure to maximise asset availability, improve operational resilience and protect critical infrastructure from unexpected failures. Across every application, transformers remain fundamental to maintaining reliable power, safeguarding revenue and ensuring long-term performance.

Transformers remain fundamental to maintaining reliable power, safeguarding revenue and ensuring long-term performance.



Wind Energy

Wind generation continues to grow worldwide, delivering clean electricity at utility scale. Operating in demanding environments and under highly variable loading conditions, wind assets require continuous visibility to maintain reliability and protect generation revenue.



Solar Energy

Solar farms experience daily thermal cycling and increasing utilisation, placing greater demands on critical electrical infrastructure. Protecting transformer health is essential to maximising energy production and long-term project returns.



Battery Energy Storage Systems (BESS)

Battery storage is becoming central to modern power systems, enabling greater renewable integration, balancing demand and supporting grid stability. As these assets become increasingly valuable, ensuring the resilience of supporting electrical infrastructure is critical to reliable operation.



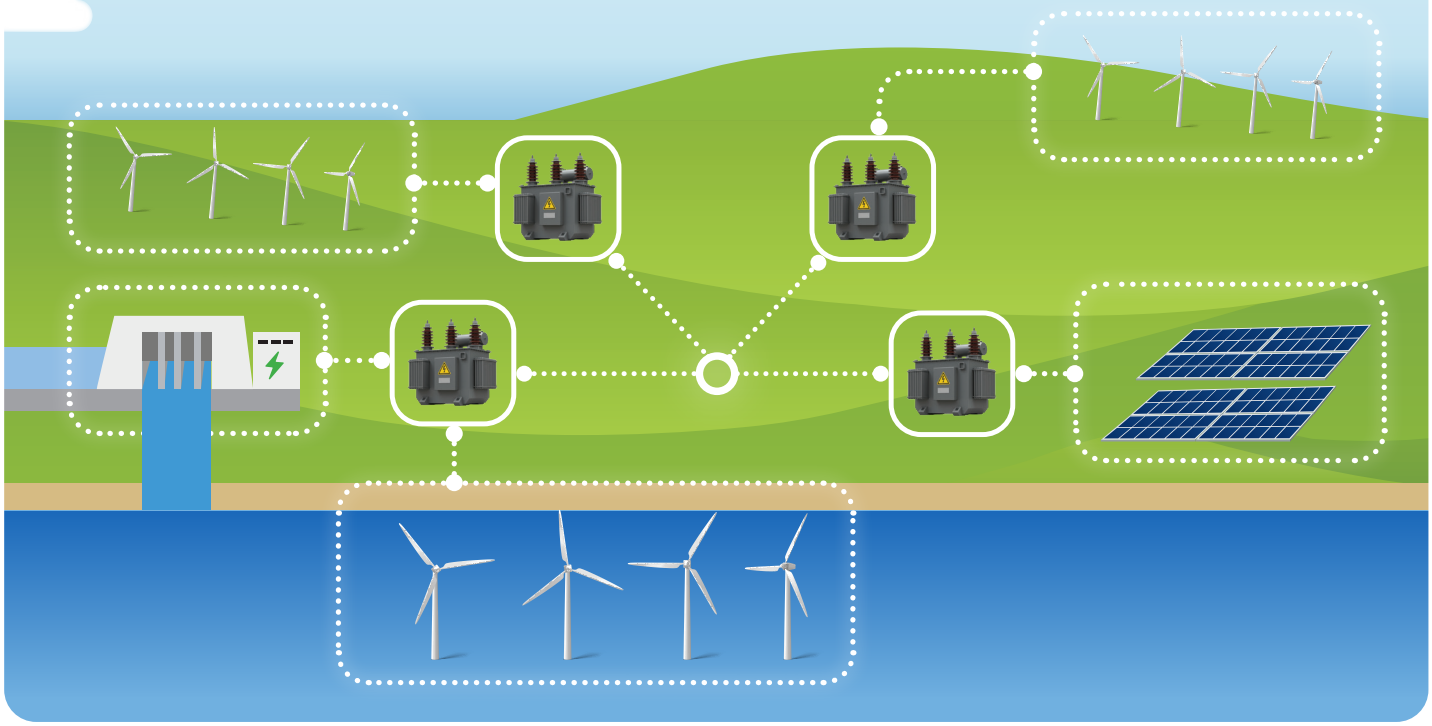
Data Centres

Data centres depend on resilient electrical infrastructure to deliver uninterrupted service. As power demands continue to increase, maintaining the health of critical transformers is essential to protecting uptime, supporting business continuity and reducing the operational risks associated with unexpected failures.

The Role of the transformer

Transformers are the backbone of modern electrical infrastructure, connecting renewable generation and critical power applications to the grid. Their reliability is fundamental to maintaining asset availability, protecting revenue and ensuring business continuity.

As one of the most valuable and vulnerable assets within the network, transformer failures can have significant operational and commercial consequences. Continuous monitoring provides the visibility needed to identify emerging risks early, strengthen resilience and support smarter, data-driven asset management.



Hybrid Renewable Energy Systems

Where renewable technologies work better together.

Hybrid renewable sites combine wind, solar and battery storage to maximise energy yield, improve grid flexibility and make better use of existing infrastructure. By intelligently balancing generation and storage, operators can increase renewable utilisation while delivering a more stable and resilient power supply.

However, this greater flexibility also creates more dynamic loading conditions across critical electrical assets, making continuous transformer monitoring increasingly important.

Key challenges

- Dynamic loading from multiple generation sources
- Higher transformer utilisation
- Greater operational complexity
- Increased need for real-time asset visibility

Why do Transformers fail?

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 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 renewable energy 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 renewable energy introduces challenges related to voltage fluctuations and grid instability, placing further strain on transformers.

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. 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).

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.





Transformer failure
can cost up to
£22 million
and take **18 months**
to replace.

The Solution

Investing in a transformer monitoring program

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 renewable energy ecosystem, Camlin Energy 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.

Predictive maintenance provides real-time insights into transformer health, helping detect issues before they escalate into costly failures





Monitor



Software



Services

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Monitor

TOTUS

Providing a DGA profile of 9 gases, TOTUS transformer monitor presents a proven solution tailored for renewable 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

TOTUSPRO and Sapient

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 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.



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.

Asset Insights

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 renewable 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.

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Key Features

Failure Impact Analysis

Targeted assessments combine real time asset health insights with impact analysis, enabling operators to prioritise resources and focus investment where failures would have the greatest operational or commercial consequence.

Predictive Analytics

Advanced analytics identify emerging risks early, allowing proactive intervention to prevent outages, protect generation availability, and extend the operational life of renewable assets.

Prescriptive Actions

Intelligent, automated recommendations align maintenance activities with operational and business objectives, streamlining workflows, improving efficiency, and maximising return on asset investment.

Strategic Benefits

Optimised Capital Investment

Extend asset life and strengthen capital plans by identifying and addressing risk early reducing unnecessary spend while maintaining high levels of reliability.

Improved Network Reliability

Minimise major failures by prioritising high risk assets, enhancing overall resilience and delivering measurable improvements in SAIDI and SAIFI performance.

Actionable Data Intelligence

Bring disparate data into a single, unified platform—removing silos and enabling confident, predictive, and informed decision making.

Operational Efficiency Gains

Increase reliability and efficiency through preventative strategies supported by a centralised insights hub, streamlining operations and improving day to day performance.



Case Study Spotlight

Transformer Monitoring for Wind Farms

A major UK wind farm experienced a catastrophic transformer failure that resulted in a five month outage and more than £10 million in lost revenue. The root cause was an undetected bushing failure, something that could have been identified early with online monitoring.

With transformers acting as single points of failure for most wind farms, unexpected outages can lead to severe financial loss, long replacement lead times, and significant disruption due to today's challenging supply-chain environment.

To safeguard against future failures, this wind generation company partnered with **Camlin Energy** to deploy the **TOTUS transformer monitoring solution** across more than **600MW of generation capacity**. TOTUS integrates dissolved gas analysis, partial discharge, and bushing monitoring into one system, delivering real-time insights supported by advanced analytics and Camlin's expert transformer engineers.

Bushing failures account for around **17% of transformer failures**, and nearly a third of this result in fire or explosion. By detecting early signs, such as changes in leakage current or electrical arcing, TOTUS provides immediate alerts that allow asset managers to take corrective action before a fault becomes catastrophic.

Proactive monitoring

This proactive monitoring approach significantly reduces operational risk, prevents prolonged outages, and protects revenues. Through this partnership, Camlin Energy is helping the wind farm operator strengthen asset reliability, reduce downtime, and maximise long-term performance.



Services

Expert Services

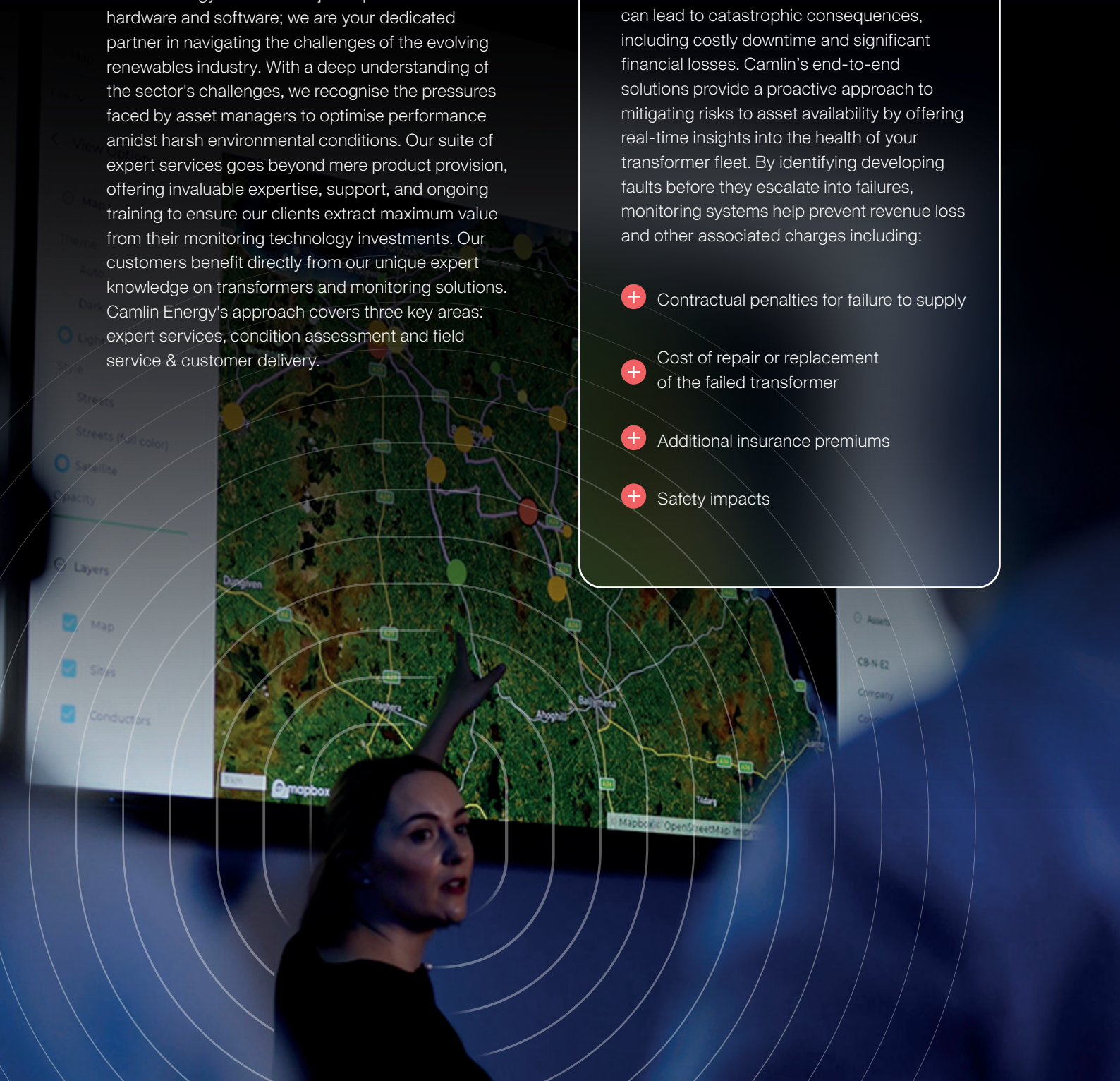
Camlin Energy is more than just a provider of hardware and software; we are your dedicated partner in navigating the challenges of the evolving renewables industry. With a deep understanding of the sector's challenges, we recognise the pressures faced by asset managers to optimise performance amidst 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. Camlin Energy's approach covers three key areas: expert services, condition assessment and field service & customer delivery.

Safeguarding commercial success

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. Camlin'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



Conclusion

Protecting the future of renewable energy

As renewable energy continues to expand, the resilience of the infrastructure supporting it has never been more important. Increasing demand, higher asset utilisation and more dynamic operating conditions mean operators must move beyond reactive maintenance towards smarter, data-driven asset management.

Transformers remain one of the most critical assets within every renewable energy network. Protecting their health is fundamental to safeguarding generation, maintaining grid connections and protecting long-term revenue.

Camlin Energy combines industry-leading transformer monitoring, intelligent software and specialist engineering expertise to help renewable asset owners reduce risk, maximise availability and make better-informed operational decisions. Together, these capabilities provide the confidence to optimise performance today while building resilience for the energy networks of tomorrow.

Whether supporting wind, solar, battery energy storage or hybrid renewable systems, our end-to-end solutions enable operators to detect faults earlier, extend asset life and protect the commercial success of their renewable investments.

Because protecting critical assets means protecting the future of renewable energy.









Discover how Camlin Energy's end-to-end transformer monitoring solutions can help maximise asset availability, reduce operational risk and optimise the performance of your renewable portfolio.

camlinenergy.com



Group Headquarters

31 Ferguson Drive
Knockmore Hill Industrial Park
Lisburn BT28 2EX
Northern Ireland

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