



Case study:

# Transformer monitoring for wind farms



camlin energy



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# A major UK wind farm could have avoided £10 million in lost revenues with online bushing monitoring



### Background

The substation transformer connecting a wind farm to the grid is a single point of potential failure in most projects. Although the transformer has a design life that nominally is longer than the typical 25-year life of the wind farm, these critical assets can and do develop faults at any stage of their life, potentially leading to significant unexpected outages and lost generation.

### Impact of transformer failure

Camlin Energy recently engaged with a leading UK wind generation company following a catastrophic failure on an unmonitored substation transformer at one of their major onshore wind farm projects. **The failure resulted in five months of unplanned outage and lost revenues** as it took five months for the project to source and install a replacement transformer. The transformer failed due to a bushing failure – without online monitoring, it was not possible to detect the developing fault and take preventative action.

The financial impact this failure had on the wind farm was significant. A five-month outage on a 100MW project would equate to lost revenues of over **£10m<sup>1</sup>** at today's electricity prices. This does not include the additional costs involved in replacing the transformer and any liabilities for the power not provided to the grid, unexpected outages and lost generation.

### Supply chain challenges

Following the catastrophic transformer failure, the UK wind farm project suffered a five-month outage until it was able to source a replacement transformer.

Supply chain lead times have significantly increased over the past few years, and lead times of more than 18 months are not uncommon for transformers.

<sup>1</sup>Calculated assuming an electricity price of £104/MWhr (2021 prices) and a 100MW farm with an average load capacity factor of 35% and an outage of 150 days.

A photograph of a wind farm with several white wind turbines on a grassy hill. The sky is a clear, deep blue. A large red rectangular box is overlaid on the left side of the image, containing white text and quotation marks.

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For approximately 17% of transformer failures, **bushings** are the component causing the failure.

”



## The solution

To mitigate against similar losses occurring in the future, the wind generation company needed a solution that would provide real-time visibility of the health of each transformer in their fleet. Online monitoring can provide valuable insights into the correct actions that are necessary to prevent a fault developing into a failure.

They chose to deploy Camlin Energy's TOTUS transformer monitoring solution on their major wind farm projects to protect over 600MW of generation capacity (protecting over £500,000 of revenues per day<sup>2</sup>). TOTUS is a single solution integrating online dissolved gas analysis, partial discharge, and bushing monitoring. Combined with sophisticated data analytics tools and transformer models supported by our in-house transformer experts, TOTUS provides real-time actionable insights for each transformer.



“  
**TOTUS provides real-time actionable insights for each transformer.**

”



### Why include bushing monitoring in your transformer monitoring solution?

For approximately 17% of transformer failures, bushings are the component causing the failure.<sup>3</sup> When bushings fail, their failures are often catastrophic with approximately 30% of bushing failures causing an explosion or fire.<sup>4</sup> Following such an event, the transformer often needs to be fully replaced or returned to the supplier for repair.



*“When bushings fail, their failures are often catastrophic with approximately 30% of bushing failures causing explosion or fire.”*

<sup>2</sup> Calculated assuming an electricity price of £104/MWhr (2021 prices), 600MW of generation capacity with an average load capacity factor of 35%.

<sup>3</sup> Transformer reliability survey: CIGRE 642

<sup>4</sup> Transformer Bushing Reliability report: CIGRE 755

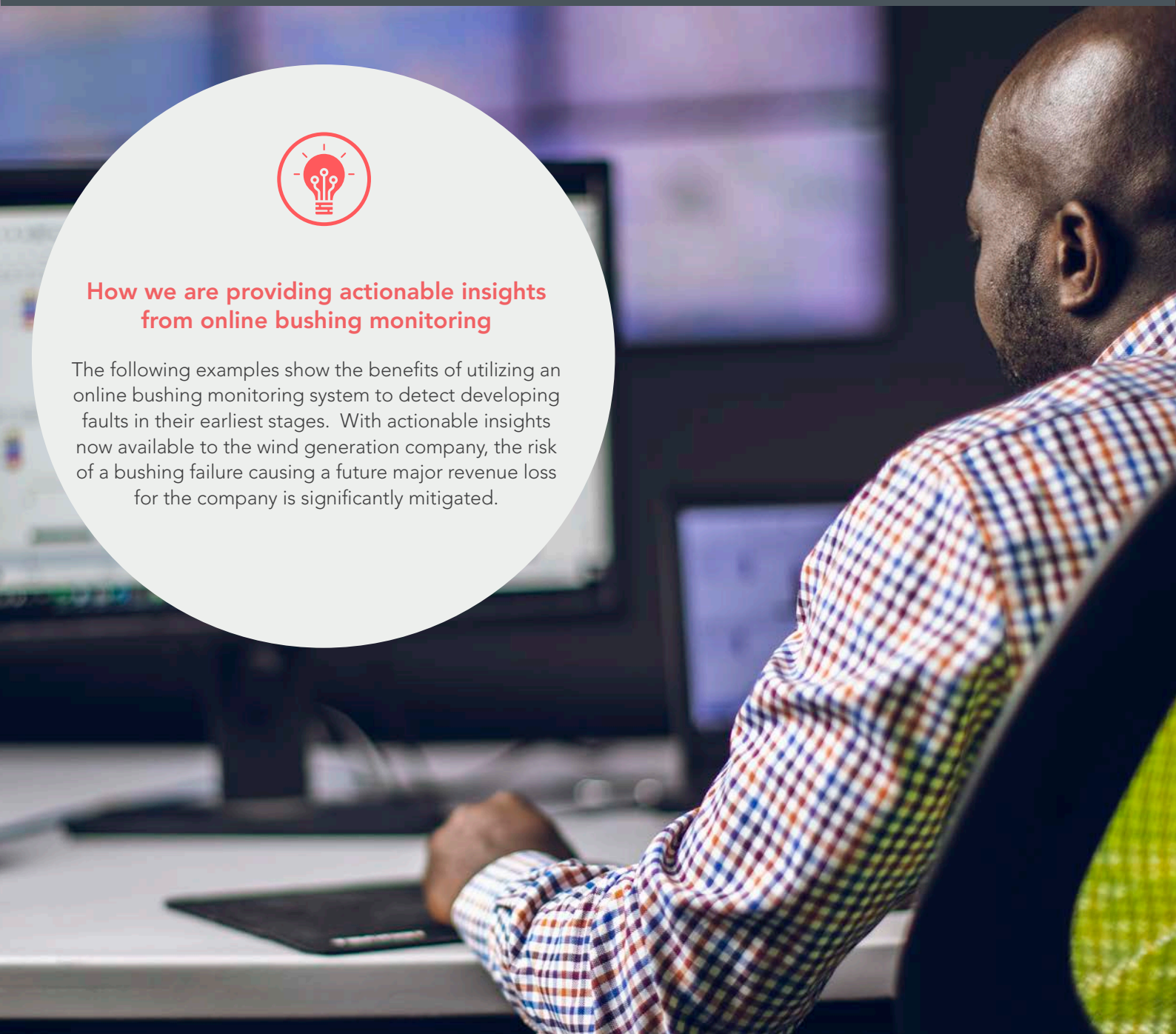
A bushing monitoring system provides the early warning of developing faults at their incipient stages by detecting changes in leakage currents and/or electrical discharges occurring inside the bushing. Early action can then be taken to replace the problematic bushing before the fault develops to a failure. This prevents potential catastrophic failure of the transformer and prolonged outage and lost revenues for the wind farm.

*A bushing monitoring sensor installed on the bushing capacitance tap.*



### **How we are providing actionable insights from online bushing monitoring**

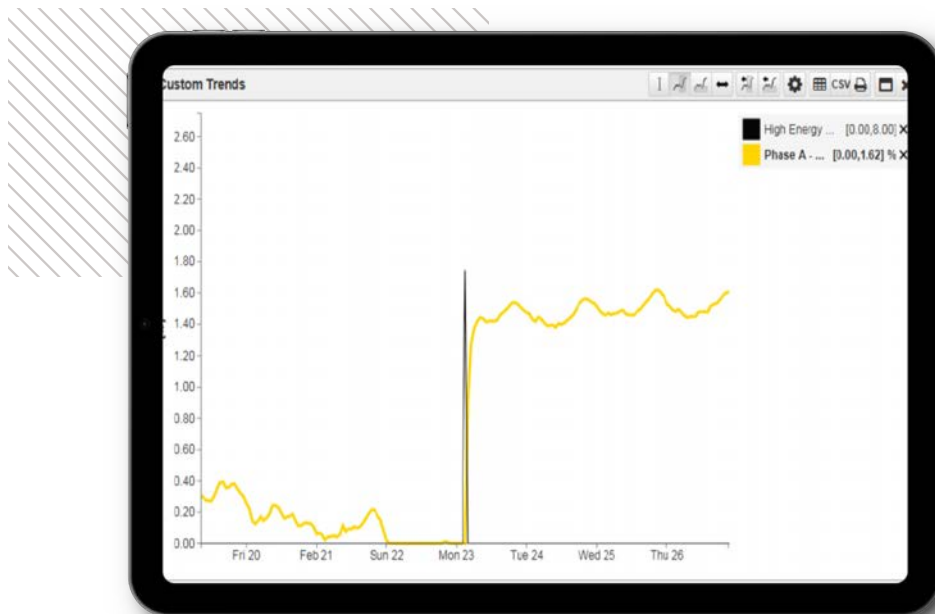
The following examples show the benefits of utilizing an online bushing monitoring system to detect developing faults in their earliest stages. With actionable insights now available to the wind generation company, the risk of a bushing failure causing a future major revenue loss for the company is significantly mitigated.





## 1: Detection of faulted layers in the bushing

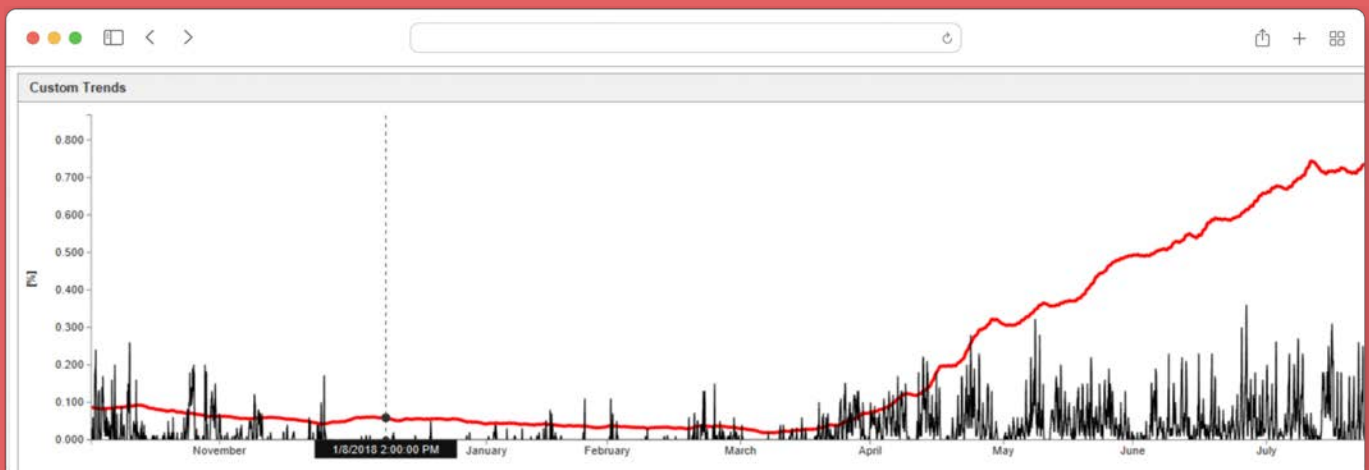
In the figure below, the yellow trend line shows the percentage change in capacitive current in the bushing, as measured by TOTUS. At the exact moment when the capacitive current abruptly increases, we see the system also detects electrical arcing inside the bushing. Without continuous online monitoring, the correlation of these phenomena would not have been detected.



The moment when the online monitoring sensors detect capacitive current abruptly increases and simultaneously arcing events occurring, is the exact moment when a portion of the bushing insulation faults. This event is occurring at the very incipient stages of the bushing fault. An alert from the monitoring device on this event allows asset managers to take corrective action and remove the bushing before a catastrophic failure occurs.

## 2. Detection of contamination inside the bushing

In the example below, a percentage change in resistive 'lossy' current through the bushing insulation is detected by the online bushing monitoring (the red trend line). The black pulse currents are electrical discharges occurring inside the bushing and detected by the online bushing monitoring system. The electrical discharges become more frequent as the resistive loss current increases. This case shows the detection of contamination inside the bushing, highlighting the need for the bushing to be replaced before a major failure occurs.



## Conclusion

The transformer connecting the project to the electricity grid is often a single point of failure in a renewable project. It is becoming more common that asset managers are seeking to implement online monitoring solutions as part of their operations and maintenance program. Asset managers need the ability to obtain real-time visibility of any risks developing in the balance of plant in their projects, and to enable timely and preventative action to be taken.

Following the case described here, Camlin Energy has entered into a partnership with this customer to implement online transformer monitoring across their wind farm fleet as a key pillar in their asset management program. By helping safeguard the connection to the grid, we support them in avoiding failures and downtime and the consequent lost revenues and damages.

## About Camlin Energy

For over two decades, Camlin Energy has been working collaboratively with customers spanning across the global energy industry to accelerate network performance and drive a more sustainable future.

Partnering with world-leading wind generation farms, energy utilities and data centre operators, Camlin Energy 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 solution, TOTUS.

Monitoring the most critical components of a transformer, TOTUS delivers actionable insights which optimize 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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