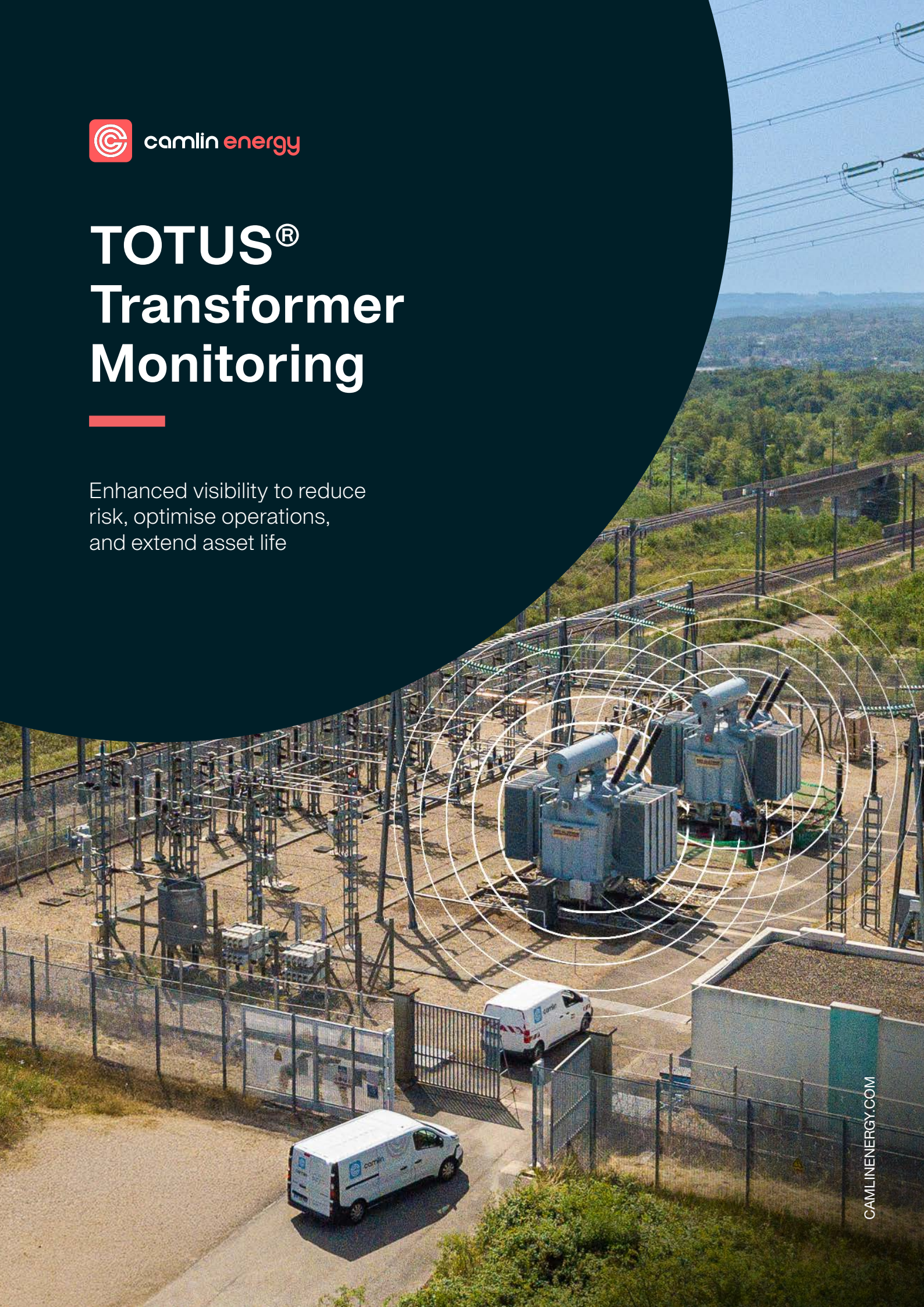




TOTUS[®] Transformer Monitoring

Enhanced visibility to reduce
risk, optimise operations,
and extend asset life



Contents

	Page
The Evolution of Transformer Asset Management	03
Why Camlin Energy: More Than Transformer Monitoring	04
Most Transformer Failures Rarely Happen Without Warning	04
Introducing TOTUS	10
Technology Spotlight	10
Bushing Intelligence	11
Partial Discharge Intelligence	12
OLTC Intelligence	12
Through-Fault Intelligence	13
TOTUSPro	14
Sapient Asset Insights	14
Experts	15
Why Customers Choose Camlin Energy	17

The Evolution of Transformer Asset Management

Today, ageing fleets are being asked to operate under greater loading, more variable conditions and increasingly complex network demands. Electrification is driving new demand, the onset of renewable generation is changing power flows, and the rapid expansion of data centres is placing unprecedented pressure on network capacity and reliability.

At the same time, utilities face growing skills shortages and fewer opportunities to take critical assets offline for inspection and maintenance.

As grid demands accelerate, transformers are being pushed harder, expected to last longer, and becoming increasingly difficult to manage with confidence.

Asset owners need to understand not only the condition of individual transformers, but how risk is developing across the fleet and where intervention will have the greatest impact.

The challenge is knowing



Which assets are becoming higher risk?



Which assets need attention now and which can safely continue operating?



Where should limited maintenance resources be focused?

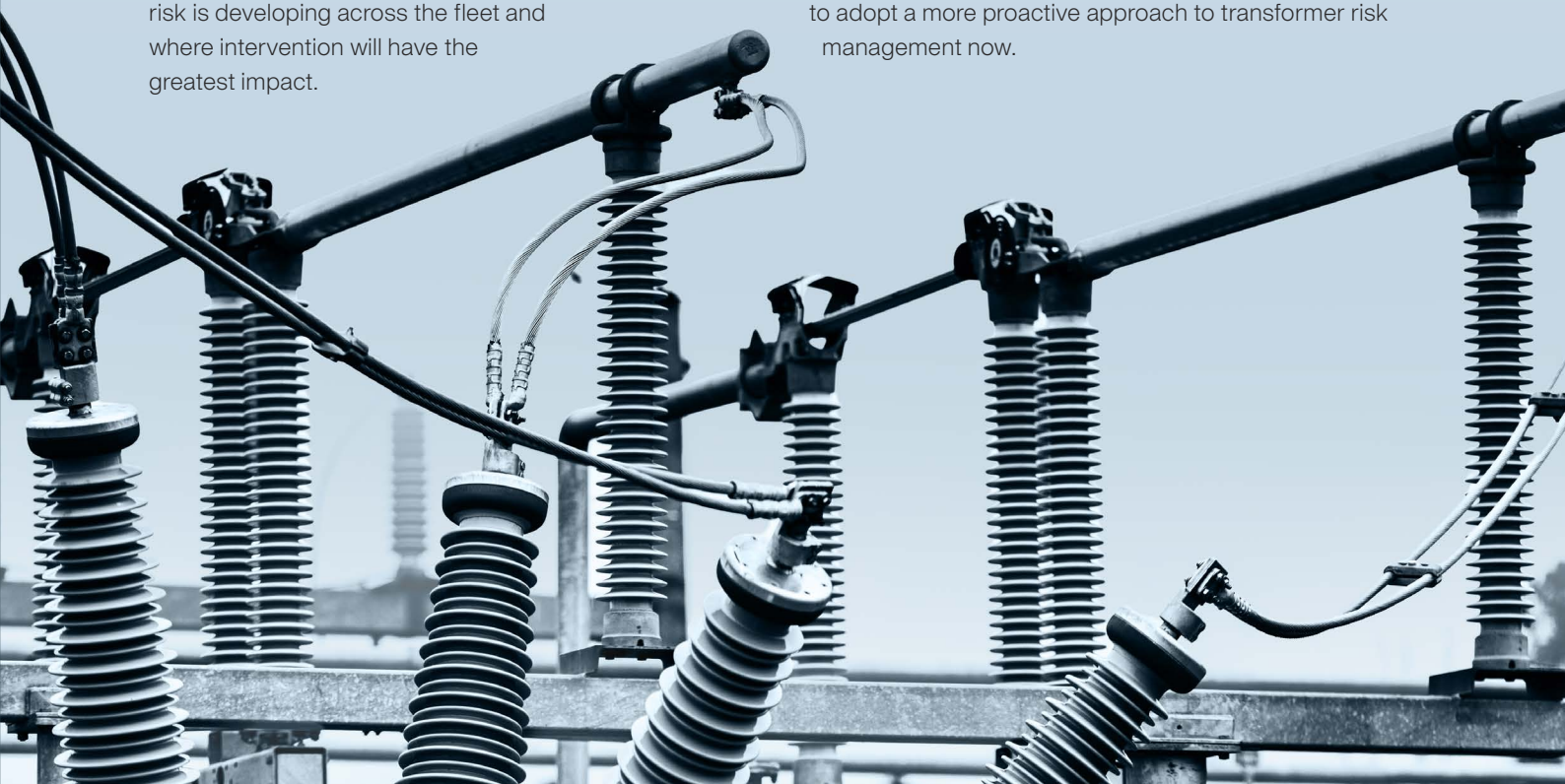


Where should capital investment be prioritised?



How can existing assets be safely utilised for longer?

Traditional periodic inspection and reactive maintenance cannot provide this level of visibility. The industry needs to adopt a more proactive approach to transformer risk management now.



Why Camlin Energy

More than transformer monitoring

Transformer owners don't need another collection of sensors, dashboards and alarms. They need a complete understanding of what is happening, what it means, and what to do next.

Camlin Energy brings together three capabilities

+ Condition Monitoring

Continuous visibility into the physical and electrical condition of critical transformer components.

+ Asset Intelligence

Advanced analytics that transform complex condition data into risk-based insights, helping asset managers understand developing failure modes and prioritise action.

+ Engineering Expertise

Specialist transformer knowledge that adds context, validates risks and supports informed decisions when the situation demands more than an algorithm can provide.

One solution. Three critical layers of value.



Sensors
visibility



Software
intelligence



Experts
confidence and action

Together, these layers of value help turn monitoring data into better asset decisions. This is the distinction between just monitoring a transformer and fully managing transformer risk.

One Platform. One Vendor. One Trusted Partner.

At Camlin Energy we support organisations to consolidate transformer monitoring through a single technology partner. Asset owners benefit from a single solution provider, streamlined operations, consistent data quality, and a common user experience across their fleet. The result is lower complexity, reduced total cost of ownership, and greater confidence in the decisions that protect critical assets and network reliability.

Camlin Energy: Supporting the journey from data to confident decision-making

More data doesn't automatically mean better decisions. Modern transformers can generate enormous volumes of condition information. The challenge is turning that information into something useful.



Asset owners need

+ Earlier detection

Identify abnormal behaviour before it becomes a failure.

+ Clearer diagnosis

Understand what is happening and which failure mode may be developing.

+ Better prioritisation

Distinguish the assets and issues that genuinely require attention.

+ More confident decisions

Know when to intervene, when to monitor and where to invest.

Turning data into decisive action



Visibility

See what is happening.



Insight

Understand what it means.



Confidence

Know what to do next.

Most transformer failures rarely happen without warning

In most cases, transformer degradation develops over time. Thermal stress, electrical and mechanical stress, insulation degradation and repeated fault exposure can create conditions that worsen over time before resulting in failure.



Three areas are particularly important

1

Windings

Thermal and mechanical stresses can progressively weaken winding insulation and structure. Repeated through-fault events can impose forces that may not cause immediate failure but can accumulate over the asset's life.

40%
of transformer
failures

2

Bushings

Insulation deterioration, increased leakage current, capacitance changes and partial discharge can indicate developing bushing problems before a catastrophic failure occurs.

17%
of transformer
failures

3

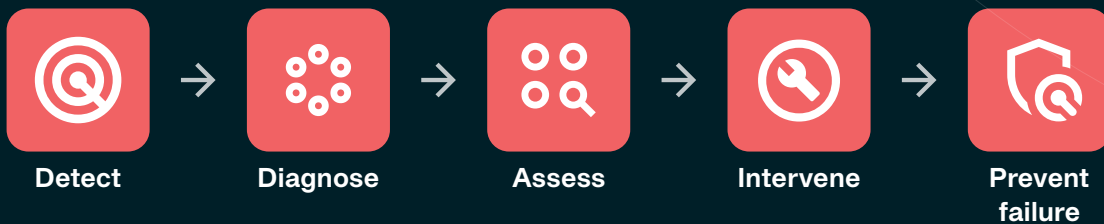
OLTCs

Repeated mechanical operation, electrical stress, contact wear and abnormal operating conditions can progressively degrade an OLTC.

26%
of transformer
failures

The greatest opportunity to prevent failure is before it happens.

A developing fault creates a window in which an asset owner may be able to:



Without continuous monitoring, these indicators can go unnoticed until a minor issue becomes a major failure. Continuous monitoring enables earlier detection, more accurate diagnosis, and timely intervention.



Some transformer problems develop over years. Others can escalate in hours.

The challenge is knowing what is actually happening inside your asset.

Continuous online monitoring solutions can help to minimise:

- + Unplanned outages
- + Emergency repairs
- + Replacement transformer costs
- + Extended asset downtime
- + Safety risks
- + Customer disruption
- + Regulatory consequences
- + Lost generation or production
- + Accelerated capital expenditure

Introducing TOTUS

**One platform. Multiple capabilities.
Built around your requirements.**

TOTUS is Camlin Energy's modular transformer monitoring platform, designed to provide comprehensive visibility across the critical components and failure modes that determine transformer health.

Rather than forcing every transformer into the same monitoring configuration, TOTUS enables asset owners to build the level of monitoring appropriate to each asset's criticality, condition and risk profile.



Modular

Deploy the capabilities required for each transformer — and expand them as requirements evolve.



Scalable

From individual critical assets to large fleets, TOTUS supports a consistent monitoring strategy across the asset base.



Integrated

Bring multiple condition indicators together through a common architecture and user experience.



Fleet-wide

Standardise transformer monitoring while tailoring diagnostic depth to the risk profile of individual assets.



The result is the ability to build a monitoring strategy that can evolve with your transformer, fleet and the network.

Modular Monitoring Capabilities

➤ DGA

Dissolved Gas Analysis

Flexible monitoring with **1, 5, or 9 gas** configurations to suit different asset criticality and diagnostic requirements.

➤ OLTC

On-Load Tap Changer Monitoring

Monitoring of tap changer operation, including tap position, motor drive activity, switching performance, and condition indicators to identify developing OLTC issues.

➤ BM

Bushing Monitoring

Monitoring of **3, 6, or 9 bushings** to identify insulation deterioration and emerging faults.

➤ TFC

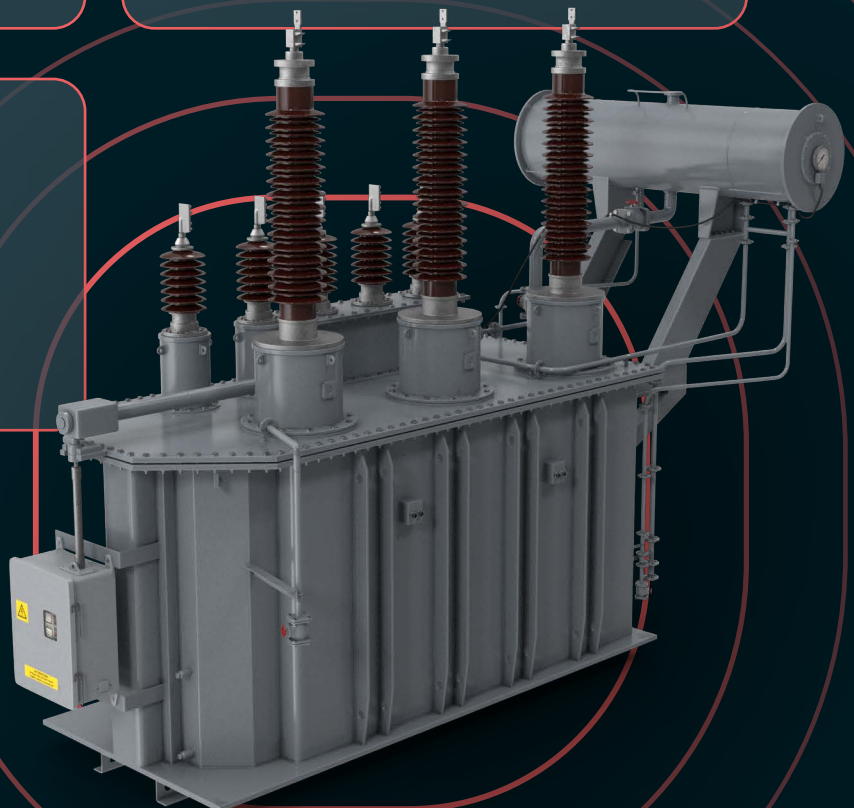
Through Fault Current Monitoring

Monitoring of through-fault events helping operators assess cumulative mechanical stress, evaluate asset condition, and support maintenance planning.

➤ PD

Partial Discharge Monitoring

Partial discharge monitoring to detect insulation defects, trend discharge activity, and ability to distinguish between faults originating in the main tank and bushings.



Technology spotlight

1

Dissolved Gas Analysis (DGA)

DGA is the most widely adopted and effective method for assessing transformer condition. By detecting gases generated by developing electrical and thermal faults, DGA provides early warning of asset deterioration, often long before issues become visible through operational performance, routine inspections, or protection systems.

As the first line of defence against unexpected transformer failure, DGA enables utilities to move from reactive maintenance to a more proactive, condition-based approach to asset management.

Not every transformer needs the same level of monitoring

A fleet-wide monitoring strategy should reflect **asset criticality, risk and required diagnostic depth.**

↘ A smarter fleet strategy

G1 Distribution Fleet

Low-cost scaling for broad fleet visibility



Designed for large-scale deployment where the priority is early indication of abnormal transformer behaviour.

- + Economical fleet coverage
- + Early fault indication
- + Broad deployment
- + Scalable monitoring

G5 Important Assets

Balanced monitoring for increased diagnostic confidence



For assets where greater diagnostic capability is justified by their importance, condition or operating environment.

- + Broader fault detection
- + Improved diagnostic capability
- + Medium-criticality assets
- + Risk-based deployment

G9 Strategic Assets

Full diagnostic insight for critical transformers



For high-value or strategically important transformers where maximum visibility and diagnostic depth are required.

- + Comprehensive DGA
- + Full diagnostic insight
- + Critical assets
- + Advanced condition assessment

2

Bushing Monitoring

Transformer bushings are among the most critical components within a power transformer, and their failure can lead to catastrophic asset damage, safety incidents, and prolonged outages. Continuous online monitoring provides early visibility of insulation deterioration and electrical activity, helping asset managers identify developing issues long before they become critical.

TOTUS supports flexible monitoring of **3, 6, or 9 bushings**, enabling monitoring strategies to be aligned with asset criticality and operational risk.

Understand developing bushing deterioration through continuous monitoring of electrical characteristics, leakage current, temperature, load and PD activity.

Source separation helps distinguish PD originating within a bushing from activity elsewhere in the transformer, supporting more targeted diagnosis.

Some of the most important transformer risks aren't revealed by a single measurement.

TOTUS continuously monitors key bushing parameters, including:

- ▶ Partial Discharge (PD) activity
- ▶ High-energy discharge events
- ▶ Leakage current magnitude and phase angle
- ▶ Temperature
- ▶ Load conditions

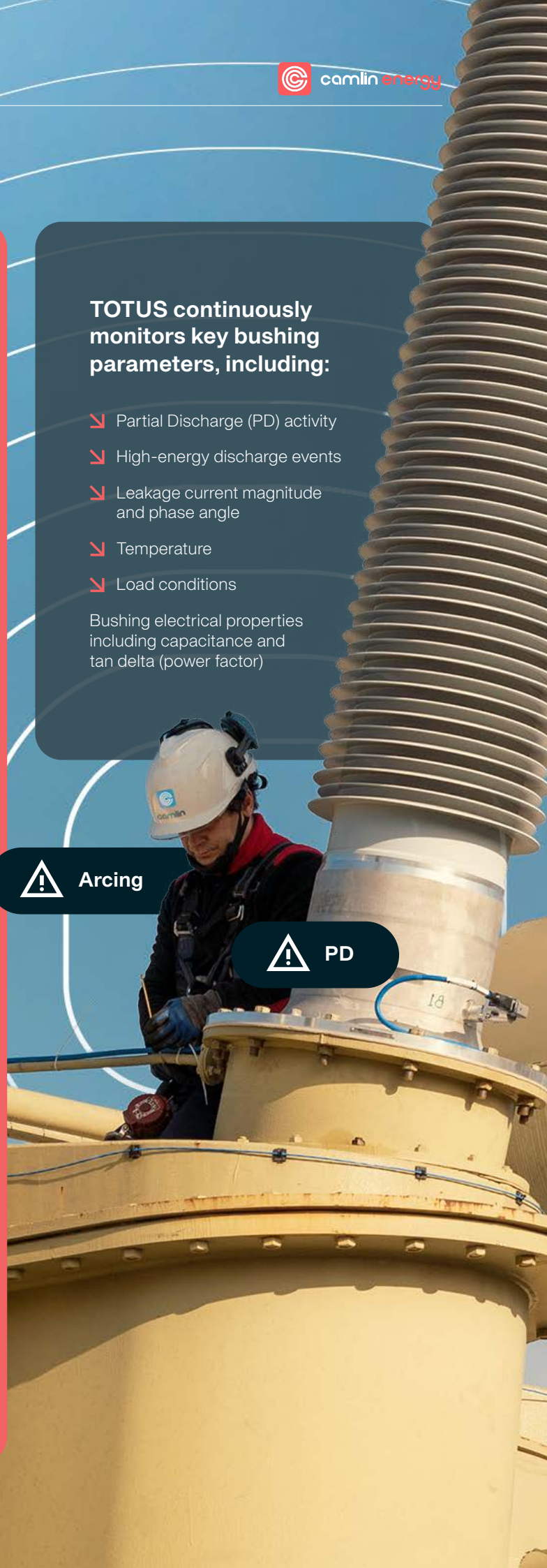
Bushing electrical properties including capacitance and tan delta (power factor)



Arcing



PD



3 Partial Discharge Monitoring

Accurate Source Separation

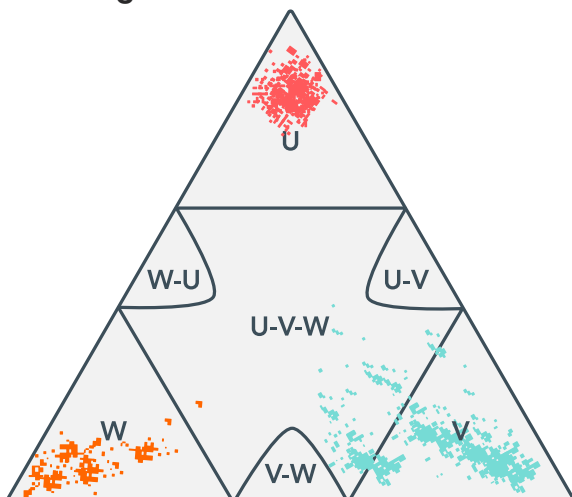
Unlike conventional monitoring solutions, TOTUS uses advanced algorithms to distinguish partial discharge activity originating in the bushing from discharge activity occurring elsewhere within the transformer. This enables more accurate diagnosis, targeted maintenance planning, and reduced risk of unnecessary intervention.

Intuitive PD Visualisation

TOTUS transforms complex PD measurements into clear, actionable information using Camlin's innovative **PD Triangle** visualisation. This intuitive approach allows operators to quickly understand PD behaviour and severity without requiring specialist analysis.

PD activity can be trended over time and correlated with other transformer parameters such as temperature, humidity, load, and DGA results, creating a more complete picture of emerging asset risk.

PD Triangle



4 OLTC Monitoring

On-Load Tap Changers (OLTCs) are the only actively moving component within a power transformer. Subjected to significant mechanical and electrical stress throughout their operating life, they remain one of the leading causes of transformer failure.

TOTUS provides comprehensive online OLTC monitoring, enabling operators to detect wear, degradation, and abnormal operating conditions before they lead to failures or unplanned outages.

Key Parameters Monitored

- Current tap position
- Operation count and switching performance
- Motor current and operating profiles
- Temperature
- Load and tap position trends

The Value of Early Detection

By identifying abnormal OLTC behaviour at an early stage, TOTUS enables a shift from routine or reactive maintenance to condition-based intervention. The result is reduced operational risk, extended component life, lower maintenance costs, and improved transformer reliability.

5

Through-Fault Monitoring

Not every damaging event causes an immediate transformer failure.

Through-faults occur when external network faults pass through a transformer outside its protection zone. While these events may not trigger transformer protection systems, their cumulative impact can progressively weaken windings and insulation, significantly increasing long-term failure risk.

TOTUS continuously monitors through-fault currents, capturing fault magnitude, duration, frequency, and energy to quantify the mechanical and thermal stresses experienced by the transformer.

Understand Hidden Asset Stress

Through-fault data is automatically trended over time and can be correlated with other transformer condition indicators. This enables asset managers to:

- Quantify cumulative winding stress
- Identify assets experiencing excessive fault exposure
- Differentiate through-fault effects from other developing issues
- Prioritise maintenance and refurbishment activities
- Reduce the risk of unexpected winding failures

By making previously hidden stresses visible, TOTUS helps utilities make more informed asset management decisions and reduce long-term reliability risk.

From monitoring data to asset understanding

Not every transformer health parameter can be measured directly. Variables such as winding hot-spot temperature, insulation moisture content, overload capability and insulation ageing are often difficult to monitor using physical sensors alone.

Yet these factors have a direct impact on:

- Insulation ageing and asset life
- Thermal stress during peak and emergency loading
- Dielectric performance and failure risk

TOTUS bridges this gap. Using advanced analytics and transformer-specific models, it calculates key health indicators that cannot be measured directly, helping operators understand the condition, risk, and remaining life of their assets.

Achieve Operational awareness with TOTUSPro

TOTUSPro enables operators to quickly understand the status of their transformer by bringing all TOTUS monitoring data together in a centralised view. Intuitive dashboards make it easy to visualise asset conditions, identify emerging issues, respond to alerts, alarms and track trends over time, helping operators efficiently monitor, investigate, and assess transformer operational condition.

Software Spotlight:

Sapient Asset Insights

AWAKEN GRID INTELLIGENCE

What is Sapient Asset Insights?

Sapient Asset Insights is Camlin Energy's asset health intelligence application, designed to help utilities understand asset condition, identify emerging risks and prioritise action across their transformer fleet.

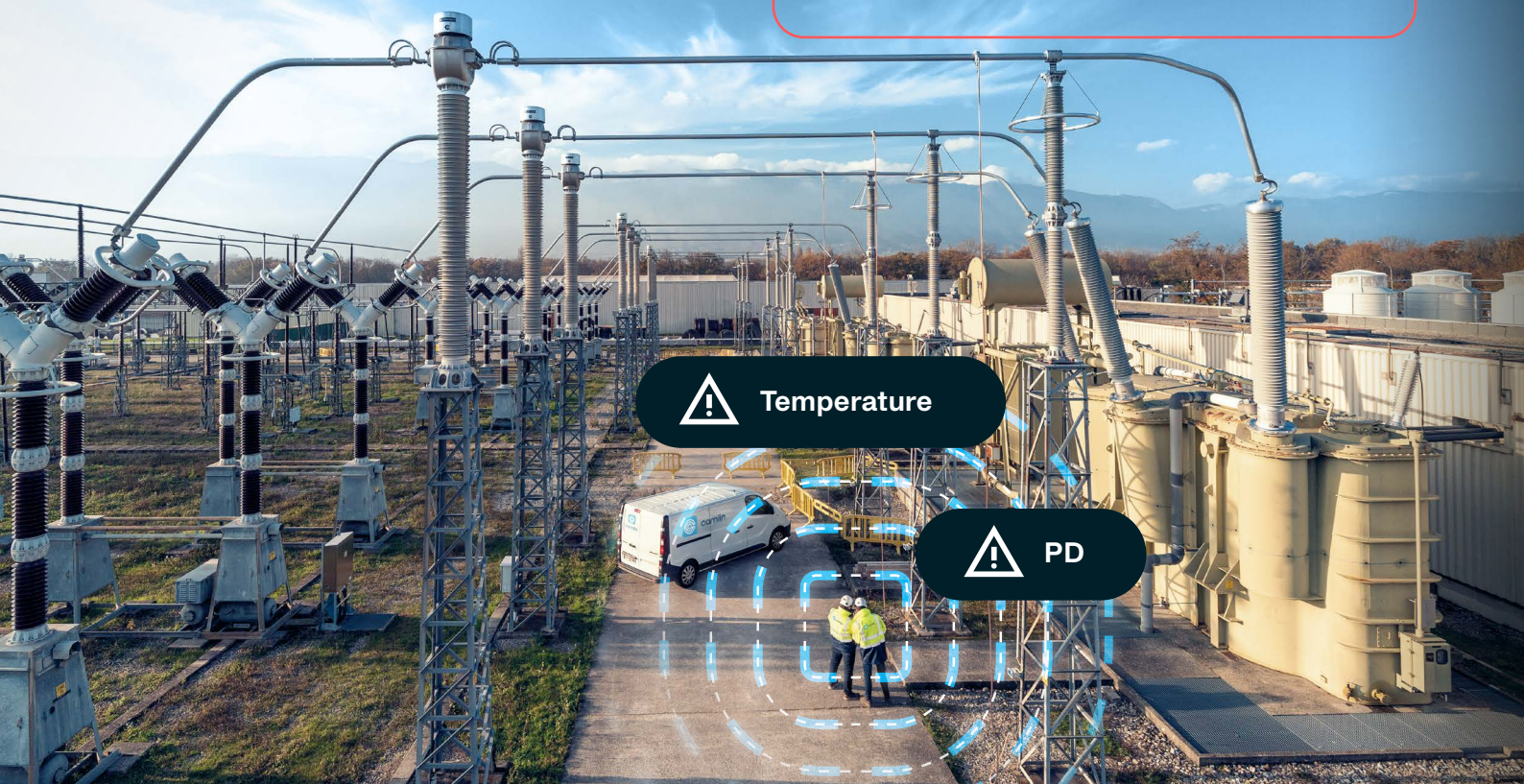
Powered by Sapient, Camlin's intelligence engine, the application combines transformer monitoring data, offline test results, maintenance history and asset information into a single intelligence platform, transforming complex data into actionable asset insights.

Rather than simply displaying asset data, Sapient Asset Insights helps organisations understand:

- Which transformers require attention
- What issues are developing and how severe the risk is
- What actions should be prioritised
- Where maintenance and investment should be focused

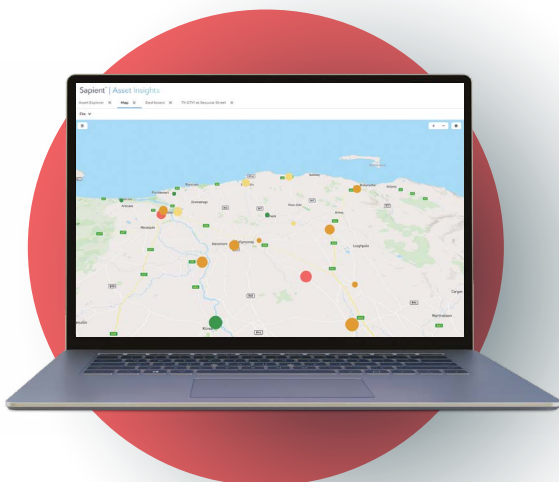
Sapient Asset Insights bridges the gap between monitoring and decision-making by combining monitoring data with engineering expertise, analytics and diagnostic intelligence.

The result is a clearer understanding of asset health and greater confidence in operational, maintenance and investment decisions.



Key Features

- + Unified Asset Health View - Bring together online monitoring data, offline test results, maintenance records and asset information within a single platform, providing a more complete picture of transformer condition.
- + Automated Health and Risk Assessment - Apply engineering-led analytics and proven diagnostic methodologies to assess asset condition, identify emerging issues and understand potential failure risks.
- + Failure Mode Identification - Move beyond alarms and thresholds to understand the likely causes of deterioration and developing asset issues.
- + Fleet Prioritisation - Identify the assets that present the greatest operational and business risk and focus resources where they will deliver the greatest impact.
- + Actionable Recommendations - Receive guidance that supports maintenance planning, investigation activities, refurbishment programmes and replacement decisions.
- + Enterprise Reporting and Dashboards - Provides engineering, operations and asset management teams with a consistent view of fleet performance, asset condition and maintenance priorities.



Why it is Critical to a Successful Monitoring Strategy

Monitoring devices tell you what is happening, Sapien Asset Insights helps you understand why it is happening and what to do next.

Without a structured asset intelligence capability, organisations risk:

- Missing critical indicators across multiple data sources
- Inconsistent engineering assessments
- Delayed intervention on high-risk assets
- Reactive maintenance practices
- Poor prioritisation of resources and investment

By transforming monitoring data into actionable intelligence, Sapien Asset Insights helps organisations maximise the value of their monitoring investments and move towards a more proactive, condition-based asset management strategy.

Customer Benefits

+ Reduce Risk

Identify emerging issues earlier and understand potential failure risks before they impact network performance. .

+ Improve Reliability

Prioritise attention on critical assets and reduce the likelihood of unexpected failures and outages

+ Scale Engineering Expertise

Apply consistent engineering methodologies across the fleet and reduce dependence on limited specialist resources.

+ Optimise Maintenance Spend

Focus maintenance activities where they are needed most and avoid unnecessary interventions.

+ Improve Investment Planning

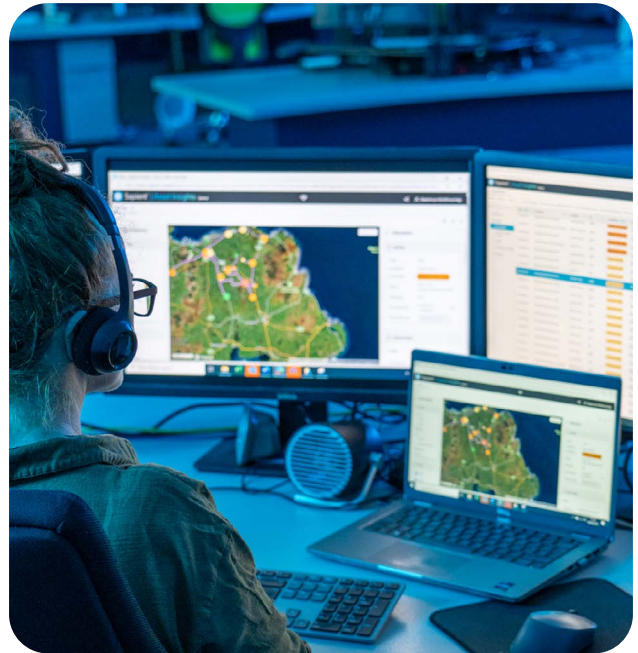
Support investment decisions with a clearer understanding of asset condition, risk and business impact.

+ Maximise Monitoring Value

Unlock greater value from transformer monitoring by turning asset data into actionable intelligence.

Building the Future of Asset Intelligence

Transformer monitoring is evolving. The future of monitoring is no longer about adding more sensors or generating more data. It is about connecting monitoring, analytics and expertise to create a deeper understanding of asset condition throughout the entire asset lifecycle.



The next generation of asset management



Future value will come from combining

- + Increasingly comprehensive monitoring
- + Advanced analytics and AI
- + Engineering expertise
- + Fleet-level intelligence
- + Lifecycle asset understanding
- + Integration with wider enterprise and grid systems

This is where the broader Camlin ecosystem becomes important.



The question is no longer

"How do we monitor this transformer?"

It becomes

"How do we continuously understand, predict and optimise the performance of this asset throughout its life?"

Experts

Camlin's Expert Services provide the final layer of intelligence. Our specialists combine engineering expertise, industry-wide knowledge, and situational awareness to interpret complex transformer behaviour beyond what the data alone can reveal.

By considering factors such as asset history, network conditions, fleet performance, operational context, and broader industry experience, they help asset owners understand developing problems, anticipate future risks, and make confident, informed decisions about the right course of action.

Software can process millions of data points. Experts provide the context, experience and judgement required when the consequences of a decision are significant. Together, they give asset owners confidence that they are acting at the right time, with the right evidence and the right operational plan.

*The right expertise.
At the right time.*

Expertise across the asset lifecycle

+ Advanced diagnostics

Investigate emerging issues and assess asset risk.

+ Failure investigation & forensics

Understand what happened, why and how future occurrences can be prevented.

+ Data interpretation

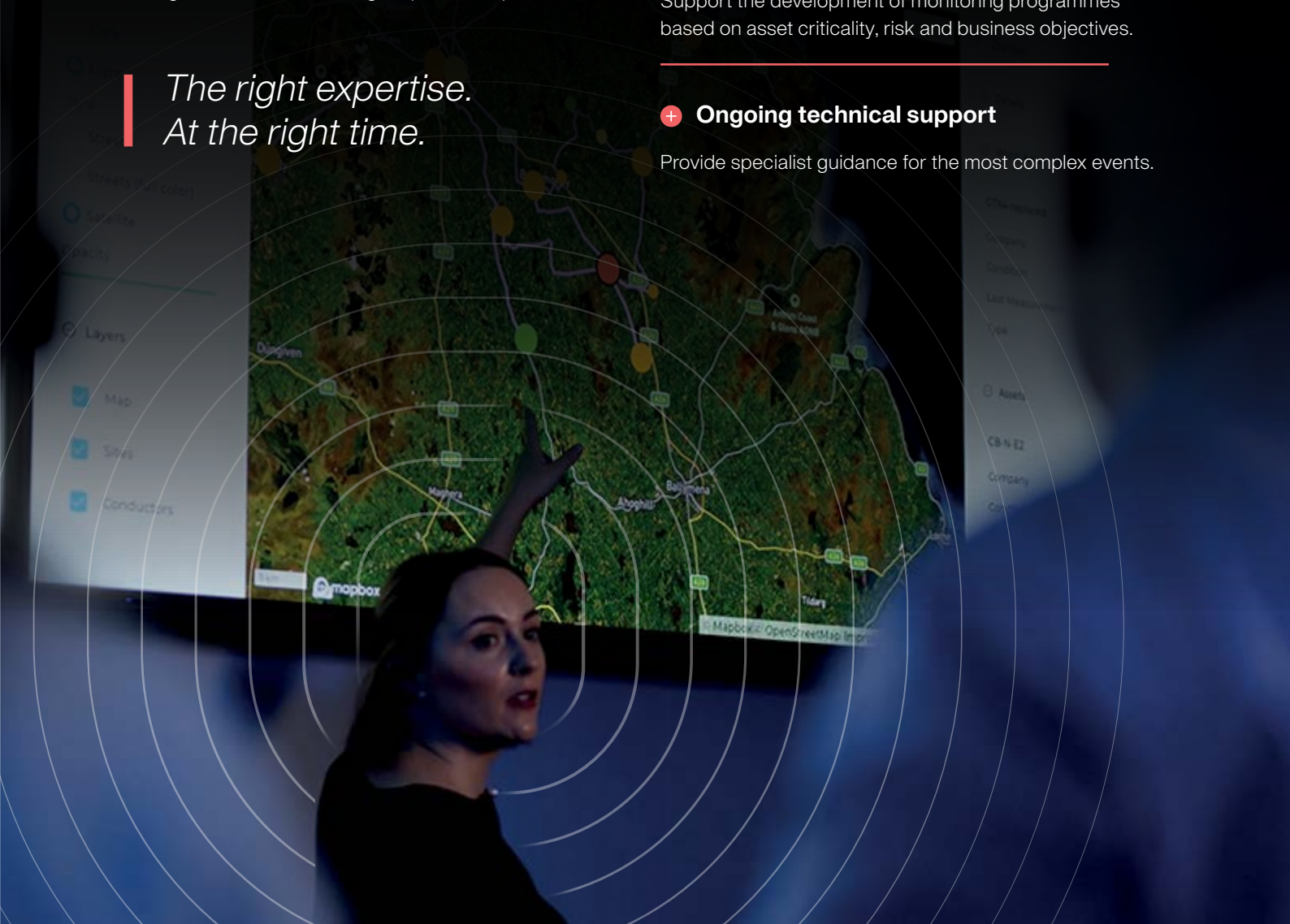
Separate genuine deterioration from normal operating conditions.

+ Monitoring strategy

Support the development of monitoring programmes based on asset criticality, risk and business objectives.

+ Ongoing technical support

Provide specialist guidance for the most complex events.



Why Customers Choose



camlin energy

1

Flexible transformer monitoring

Build the right monitoring strategy for every transformer - from broad fleet coverage to advanced diagnostics for critical assets.

2

End-to-end transformer risk management

Bring monitoring, intelligence and expertise together through one integrated approach.

3

Asset intelligence and analytics

Turn complex condition data into clearer understanding, prioritised risk and actionable decisions.

4

Deep transformer expertise

Combine technology with decades of engineering knowledge, diagnostics and real-world transformer experience.

5

A partner for the future

As transformer fleets evolve and grid demands increase, Camlin provides the technology, intelligence and expertise to help asset owners manage risk throughout the asset life cycle.







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