



# A €9,000 Intervention That Prevented a €2M Catastrophic Failure for a Leading French Utility

CASE STUDY





## CHALLENGE

Preventing Transformer Failure in a Critical Hydro Asset

A 90MVA, 230/66kV transformer connecting a hydroelectric facility to the national transmission grid served as a critical, non-redundant asset. Any unplanned outage on this transformer could have resulted in major service disruption and potential regulatory penalties. Because bushings account for roughly 30% of transformer failures, with insulation deteriorating long before a fault becomes visible, relying solely on periodic offline testing introduced significant operational and financial risk.

In an environment where long replacement lead times and multi-million euro consequences are common, early detection was essential. Early visibility keeps maintenance proactive, not reactive, and ensures uninterrupted operation of this highly critical transformer.



## EVENT

TOTUS Detects Thermally Driven Bushing Degradation

Camlin Energy's TOTUS monitoring system was installed in June 2025, providing real-time tracking of:

Power Factor (PF)

Capacitance (C1)

Temperature correlation

Findings revealed a progressive increase in power factor in late June, exceeding alarm thresholds, while capacitance deviations closely mirrored top oil temperature, indicating thermally driven insulation degradation and suggesting advanced dielectric ageing that required further investigation.

With TOTUS installed, the utility was able to **monitor the condition of the transformer bushings continuously** until the pre-planned outage, correlating elevated PF and capacitance with thermal stresses.

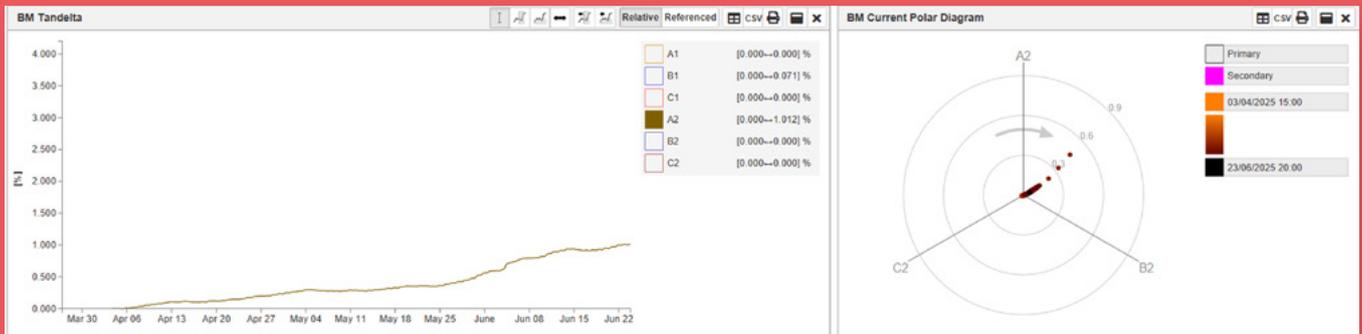
**Figure 1:**

Transformer with TOTUS installed



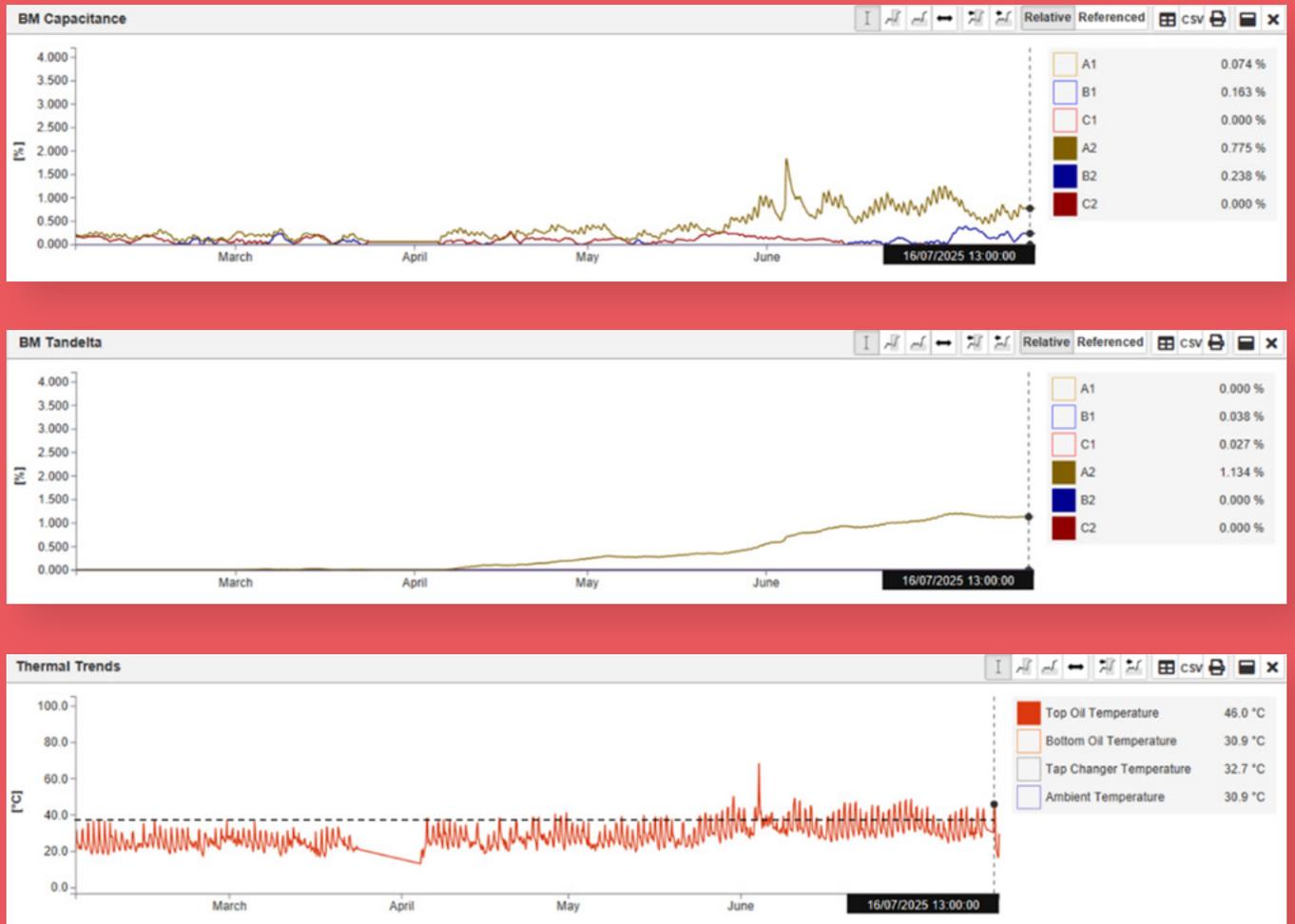
**Figure 2:**

Dissipation factor increases in secondary A-phase bushing (left), and polar plot of secondary winding's bushings.



**Figure 3:**

Thermal dependency of Capacitance (top) trend and Dissipation Factor (middle) trend, with the average temperature increase (bottom).



**Figure 4:**  
**Balayage en fréquence**

Mesure C1:

N°	1b	Mode test	UST-A						
Fréq.	V test	V out	I out	Puiss. abs.	DF mes	DF corr	Cap. mes.	Évaluation	
15,00 Hz	2,00 kV	2,00 kV	0,05 mA	2,45 mW	2,6287 %	2,6287 %	247,3 pF	N. év.	
20,00 Hz	2,00 kV	2,00 kV	0,06 mA	2,57 mW	2,0743 %	2,0743 %	246,9 pF	N. év.	
35,00 Hz	2,00 kV	2,00 kV	0,11 mA	2,87 mW	1,3261 %	1,3261 %	246,2 pF	N. év.	
50,00 Hz	2,00 kV	2,00 kV	0,15 mA	3,16 mW	1,0234 %	1,0234 %	246,0 pF	N. év.	
135,00 Hz	2,00 kV	2,00 kV	0,42 mA	4,65 mW	0,5586 %	0,5586 %	245,4 pF	N. év.	
220,00 Hz	2,00 kV	2,00 kV	0,68 mA	6,19 mW	0,4566 %	0,4566 %	245,1 pF	N. év.	
305,00 Hz	2,00 kV	2,00 kV	0,94 mA	7,80 mW	0,4153 %	0,4153 %	245,0 pF	N. év.	
400,00 Hz	2,00 kV	2,00 kV	1,23 mA	9,66 mW	0,3926 %	0,3926 %	244,9 pF	N. év.	

### Balayage en tension

Mesure C1:

N°	1a	Mode test	UST-A						
Fréq.	V test	V out	I out	Puiss. abs.	DF mes	DF corr	Cap. mes.	Évaluation	
50,00 Hz	2,00 kV	2,00 kV	0,15 mA	3,02 mW	0,9761 %	0,9761 %	245,9 pF	N. év.	
50,00 Hz	4,00 kV	4,00 kV	0,31 mA	13,67 mW	1,1056 %	1,1056 %	245,9 pF	N. év.	
50,00 Hz	6,00 kV	6,00 kV	0,46 mA	34,11 mW	1,2259 %	1,2259 %	246,0 pF	N. év.	
50,00 Hz	8,00 kV	8,00 kV	0,62 mA	65,81 mW	1,3304 %	1,3304 %	246,0 pF	N. év.	
50,00 Hz	10,00 kV	10,00 kV	0,77 mA	109,88 mW	1,4215 %	1,4215 %	246,0 pF	N. év.	
50,00 Hz	12,00 kV	12,00 kV	0,93 mA	167,05 mW	1,5004 %	1,5004 %	246,1 pF	N. év.	

**Figure 5:**

Dissolved Gas Analysis (DGA) results for A2 bushing.

	Concentration			IEC 60599 90% Typical Concentration Range
	mol mass	µmol/l	ppm	ppm
H2	2	383.1	766.2	69 - 392
O2	32	29	928.0	
N2	28	1830	51240.0	
CO	28	7.4	207.2	229 - 927
CO2	44	43.39	1909.2	484 - 11578
CH4	16	15.92	254.7	37 - 216
C2H2	26	0.15	3.9	<5
C2H4	28	0.47	13.2	2 - 70
C2H6	30	18.49	554.7	17 - 121



## ACTION

### Targeted Offline Diagnostics and Replacement

During the scheduled outage, the French utility conducted detailed offline testing to verify the condition of the bushings. On the A2 bushing Dielectric Frequency Sweep testing was performed returning a dielectric factor of 2.6287%, a value classified as extreme according to CIGRE 755 guidelines.

A fixed frequency voltage sweep showed a Power Factor of 1.4215% (approximately 6.5 times the nameplate value), indicating severe dielectric deterioration. Dissolved Gas Analysis further supported these findings, revealing elevated levels of hydrogen, methane, and ethane consistent with internal insulation degradation.

Based on this evidence, the defective A2 bushing was removed and replaced, and an internal investigation by the OEM is underway to determine the root cause of the failure.



## OUTCOME

### Avoided Catastrophic Failure and Reduced Costs

#### Technical outcome:

- ↘ Early detection prevented catastrophic bushing failure
- ↘ Insulation degradation was confirmed via offline PF and DGA testing
- ↘ Intervention was performed under **planned, controlled conditions**

#### Commercial & Operational Impact:

- ↘ Intervention cost: **€9,000** using in-house crew, spare bushing, and national reserve materials
- ↘ Avoided potential **multi-million-euro losses** from transformer damage, unplanned outages, and emergency logistics
- ↘ Maintained operational continuity and **asset availability**
- ↘ Shifted the utility from reactive response → proactive asset management