

TRANSFORMER LIFE EXTENSION THROUGH CONTINUOUS MOISTURE MANAGEMENT

A Sustainable Asset Management
Strategy for Modern Power Systems



The global power industry is under increasing pressure to improve sustainability, reduce carbon emissions, and maximize the value of existing infrastructure.

Replacing transformers prematurely due to insulation degradation carries significant environmental and economic costs.



- Reduce Carbon Footprint
- Extend Asset Life
- Delay Capital Expenditure
- Improve Reliability
- Support Sustainability Goals

A POWER TRANSFORMER CONTAINS SIGNIFICANT RESOURCES



Electrical
Steel



Copper



Cellulose
Insulation



Mineral
Oil



Manufacturing
Energy



Transportation
Resources



Every transformer replacement generates a substantial carbon footprint through manufacturing, transportation, installation, and disposal activities.



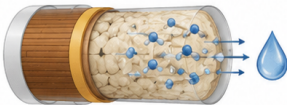
FOR THIS REASON, UTILITIES WORLDWIDE ARE INCREASINGLY ADOPTING
ASSET LIFE EXTENSION STRATEGIES AS PART OF THEIR SUSTAINABILITY PROGRAMS.



THE HIDDEN DRIVER OF TRANSFORMER AGING

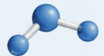
The life of a transformer is primarily determined by the condition of its oil-paper insulation system.

Among all factors affecting insulation health, **moisture is one of the most significant accelerators of aging.**



MOISTURE CONTRIBUTES TO:

- Cellulose hydrolysis
- Reduced Degree of Polymerization (DP)
- Lower dielectric strength
- Increased dielectric losses
- Increased risk of partial discharge
- Higher bubbling risk during overload conditions
- Accelerated insulation degradation



As insulation ages, additional moisture is generated within the paper itself, creating a **self-accelerating aging process.**

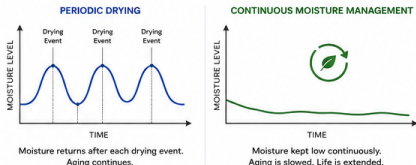
CONTINUOUS MOISTURE MANAGEMENT: FROM MAINTENANCE TO SUSTAINABILITY

Most transformer drying methods are performed periodically. While periodic drying can temporarily reduce moisture levels, moisture migration and moisture generation continue throughout the transformer's life.

- Moisture continuously moves between paper and oil as operating temperatures change.
- Aging cellulose generates moisture.
- Breathers can introduce moisture.
- Oil leaks can allow moisture ingress.

As a result, moisture control should not be viewed as a one-time activity. It should be viewed as a continuous asset management process.

PERIODIC DRYING vs. CONTINUOUS MOISTURE MANAGEMENT



Continuous moisture management is the key to slowing insulation aging and extending the life of your transformer.

THE SUSTAINABILITY BENEFITS OF CONTINUOUS MOISTURE MANAGEMENT



EXTEND INSULATION LIFE

Reducing moisture slows cellulose degradation and preserves the mechanical and dielectric strength of insulation.



IMPROVE RELIABILITY

Lower moisture levels improve dielectric performance and reduce insulation stress, leading to fewer failures and unplanned outages.



REDUCE CARBON FOOTPRINT

Delaying transformer replacement avoids the environmental impact associated with manufacturing, transporting and installing new equipment.



SUPPORT CIRCULAR ECONOMY PRINCIPLES

Maximizing the useful life of existing assets reduces consumption of raw materials and minimizes waste generation.



IMPROVE RETURN ON EXISTING INFRASTRUCTURE

Utilities can extract greater value from installed assets while maintaining safety, performance and compliance.

ALIGNMENT WITH GLOBAL SUSTAINABILITY GOALS

<p>7 AFFORDABLE AND CLEAN ENERGY</p>	<p>SDG 7 – Affordable and Clean Energy</p> <p>Longer transformer life improves grid reliability and ensures a stable supply of clean energy.</p>
<p>9 INDUSTRY, INNOVATION AND INFRASTRUCTURE</p>	<p>SDG 9 – Industry, Innovation and Infrastructure</p> <p>Extending asset life strengthens the resilience and sustainability of critical infrastructure.</p>
<p>12 RESPONSIBLE CONSUMPTION AND PRODUCTION</p>	<p>SDG 12 – Responsible Consumption and Production</p> <p>Extending the life of transformers reduces demand for raw materials and promotes responsible use of resources.</p>
<p>13 CLIMATE ACTION</p>	<p>SDG 13 – Climate Action</p> <p>Avoided replacement reduces embodied carbon emissions and supports climate action goals.</p>

KEY TAKEAWAY

“Transformer life extension is one of the most practical sustainability strategies available to power utilities today. By continuously managing moisture—one of the primary drivers of insulation aging—utilities can improve reliability, reduce environmental impact, and maximize the value of existing transformer assets.”

Moisture management is not only about protecting transformers.

It is about protecting resources, reducing emissions, and building a more sustainable power system.”



SOURCES & REFERENCES

- CIGRE Technical Brochure 349 – Moisture Equilibrium and Moisture Migration within Transformer Insulation Systems
- CIGRE Technical Brochure 323 – Ageing of Cellulose in Mineral-Oil Insulated Transformers
- IEEE C57.91 – Guide for Loading Mineral-Oil-Immersed Transformers
- IEEE C57.143 – Guide for Application of Monitoring Equipment to Liquid-Immersed Transformers
- IEC 60422 – Mineral Insulating Oils in Electrical Equipment – Supervision and Maintenance Guidance
- OMICRON Energy – Why Is Water Killing Power Transformer Insulation?
- PCIC Europe – Life Extension of Power Transformers Through Proper Moisture Management

