Sustainable transformers - Solutions to increase reliability and ease maintenance

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Sustainability encourages businesses to make decisions and engineer their products and services in terms of their environmental, social, and human impact for the long-term, rather than focusing on short-term goals such as the next year's earnings report. It attempts to coax and influence them to consider more factors than simply the immediate profit or loss involved.

The world today is modern, materialistic, and largely urbanized. Due to vastly improved technologies, digitalization, the dramatic adoption and spread of telecommunication facilities, a major transition in transportation, and smarter cities, we are consuming more resources than ever before and certainly much more than we can put back. Many indicators show that modern society consumes more resources and pollutes our planet more than it can sustain in the long term. This stands true for the global energy sector, more perhaps than any other. The modern world increasingly relies on the electrical grid. From lighting our homes and powering our phones to running factories, almost everything we do or use is made possible by electricity. With the growth of e-mobility and digitalization, we will only see demand rising. Global energy demand is expected to grow more than 25 % by 2040, with electricity becoming an increasingly relevant part of the energy mix, heralding the global move toward a more electrified world.

This widespread presence and growing demand for electricity mean that transformers are everywhere. As an essential part of the modern electrical grid, transformers increase the voltage of the system for efficient transmission over long distances and then step-down the voltage to distribute electricity to consumers. As a critical component of electrical infrastructure, strategic changes to transformer design and maintenance can minimize energy losses and reduce the environmental impact of the power grid. Therefore, as enablers of the transmission of electric energy, transformers are at the center of the system, which fuels our society, and they are affected by the issue of sustainability from several perspectives.

Sustainability encourages making decisions and developing products and services, taking into account their environmental, social, and human impacts and influences on the long-term timescale

One of the most important ways for transformers to be more sustainable and resource-efficient is through digitalization and by implementing technology that reduces downtime, which at the same time increases intervals between maintenance and extends their lifespan. This can be achieved with condition-based lifecycle management instead of traditional time-based management.

Operators can no longer afford to follow a simple time-based maintenance strategy that mitigates risks by doing everything, every year, for all transformers. Instead, they can implement a more sophisticated condition-based maintenance strategy: carrying out more maintenance for high-risk transformers than for low-risk transformers. This requires reliable information about the status of the transformers. The risk of sudden transformer failure entails not only huge replacement costs and downtime but is also hazardous to the environment and human life. It is

imperative to optimize transformer maintenance, especially because globally, the average transformer age is approaching 40 years, and replacement costs run into the millions. The opportunity to gain years of additional productivity and enhance the sustainability of such assets simply must be seized by employing cost-effective and efficient maintenance strategies.

One of the most important ways for transformers to be more sustainable is through digitalization and by implementing technology for condition-based lifecycle management

Transformer sensing and monitoring are essential components of transformer asset management; by keeping a watchful eye on the most critical transformer components, operators can optimize their maintenance planning and spending.

The benefits of monitoring are substantial. A CIGRE study has shown that transformer monitoring can reduce the risk of catastrophic failures by **50** %. It was shown that early detection of problems could reduce repair costs by **75** % and loss of revenue by **60** %. Furthermore, annual cost savings can amount to **2** % of the price of a new transformer achieving significant savings for the operator.

Monitoring a transformer amounts to tracking variations of absolute values and trends of temperatures, electrical, mechanical, and chemical indicators. These measurements are collected with sensors installed on the transformer. Hitachi ABB Power Grids offers multiple sensors, including the CoreSense™ family of sensors for dissolved gas in oil analysis. TXpert™ Ready CoreSense™ provides a non-intrusive, maintenance-free, and easy to install solution for either flagging a potential fault with hydrogen measurement or performing a deeper analysis with the multi-gas version.

The TXpert™ Hub CoreTec™ 4 is an advanced transformer condition monitor that enables real-time management of a transformer by monitoring key health parameters such as winding temperature, ambient temperature, and load. Using live data and transformer models based on IEC and IEEE standards, CoreTec™ 4 warns the operator of any changes in a transformer's condition. Variations in these key health indicators are flagged by CoreTec™ 4 in real time and can trigger advanced investigations when needed, not just when scheduled.

Hitachi ABB Power Grids is a pioneer in transformer monitoring, having introduced the first TEC system in 2001; the CoreTec™ 4 is the culmination of this legacy.

In the context of transformer asset health management, a challenge that many industries and utilities face is in the understanding and tracking of the data generated by both online and offline measurements. Many organizations try to avoid unnecessary maintenance by utilizing a variety of mixed information from multiple sources, such as inspection data, sensor trends / alarms, and industrial enterprise systems. However, most of the time, the collation, correlation, and interpretation of this data require human expertise, which, especially now, is a challenge given the scarcity of highly trained personnel.

Hitachi ABB Power Grids' solution to these issues is TXpert™ Asset Performance Management (APM) Edge. This solution combines decades of subject

TXpert™ Ready CoreSense M10 and TXpert™ Hub

TXpert™ Asset Performance Management fleet analytic software ranking transformer risk of failure enabling maintenance to be prioritised

A CIGRE study has shown that transformer monitoring can reduce the risk of catastrophic failures by 50 %, while early detection of problems could reduce repair costs by 75 % and loss of revenue by 60 %

matter expertise in transformer manufacturing and maintenance, with historical and real-time data analysis from transformer sensors. These continuous health and performance insights prevent critical asset failures while optimizing lifecycle costs. With the integration of operational and information technology, Hitachi ABB Power Grids provides the facility for the consolidation of all the asset information to provide intelligent insights on the health and potential risks to transformers.

TXpert™ APM applies expert knowledge on all the assets mapped in the system. Each asset is also categorized according to its current health condition and expected life. The result is a priority-wise risk assessment of critical assets based on their probability of failure along with actionable intelligence.

In cases when online monitoring and the diagnosis indicate a possible malfunction, one might need to drain the oil of the transformer and have a specialist enter the unit to perform an internal inspection. All this deems significant outage, risks, and considerable expense by the transformer owner.

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To mitigate the above challenges, Hitachi ABB Power Grids has developed the TXplore™ system as a remotely controlled inspection "submarine." This automated inspection completely eliminates the need to put a human at risk and expose the transformer's internal structure to external contaminants. The inspection is usually performed within a day. Based on the findings by the submersible robot, a transformer design expert provides an analytical report that reviews any problems and contains recommendations for condition improvement or for bringing the unit in for repair.

Another notable sustainability effort by Hitachi ABB Power Grids is a range of services to expand the use of and extend the value of aged transformers. While lowering the risk of fire and environmental impact, these services combine extra overload capabilities with extended life.

Retrofit or Retrofill with ester oils instead of mineral oils improves transformer safety. This biodegradable oil is made from renewable resources and minimises the environmental impact of oil spillages. It is a less flammable fluid which reduces the risk of fire and associated collateral damages.

Retrofitting is also done for upgrading the active parts of the transformer; this brings reduced losses at original ratings.

TXplore™ Inspection robot providing video fingerprint on internal transformer condition

The technology can provide an average increase in power or overload capability of 50 % or help to meet the EU energy efficiency requirements with lower losses.

The state of transformer oil and cellulose insulation is one of the key parameters influencing equipment life expectancy and reliability. Hitachi ABB Power Grids' Oil Reclamation service is an economical and environmentally friendly process that restores the properties of the transformer oil close to the values of new oil. By removing acids, sludge, and other oxidation products, the ageing rate of the oil and its effect on insulating materials is mitigated.

This is all a part of Hitachi ABB Power Grids' innovative contribution to sustainability – to enable the gathering of data on the installed base transformers and predict the future in time. Effectively utilizing digitalization and new technologies to assess the condition of the installed transformers on the fleet, treat the potentially worst cases to avoid failure and prevent environmental and monetary disasters.

As the world's biggest supplier and among the earliest, Hitachi ABB Power Grids has the exact domain knowledge from manufacturing and successfully maintaining thousands of transformers, along with the experience and ability to encompass that knowledge and serve as a partner for life for transformers.

Hitachi ABB Power Grids's APM is a solution that combines decades of subject matter expertise in transformer manufacturing and maintenance, with historical and real-time data analysis from transformer sensors

Bibliography

[1] L. Cheim et al., *Submersible Transformer Inspection Robot (STIR)*, IEEE PES 2018

[2] G. Cole et al., *Robot redefines transformer field inspections*, ABB Review 2019

[3] P. Lorin, L. Tehini, T. Reed, *Transformer asset management – Do more with less*, ABB Review 03/2018

[4] S. Pearce, *Dynamic fleet wide condition assessment for power transformers*, CEPSE 2016

[5] C. Schneider, *Transformer reliability, taking predictive maintenance program to the next level*, CIGRÉ Study Committee A2 COLLOQUIUM, October 1st- 6th, 2017, Cracow, Poland

[6] C. Stiegemeier, *Transformer maintenance best practices – Condition-based actions*, TechCon North America, 2012

[7] B. Das, *Quantifying transformer inspection attribute data using APM Edge*, 2020

[8] M. Oliva et al., *Transformers innovation in a changing energy landscape*, ARWtr 2019

[9] *Service Handbook for Transformers*, 4th edition, ABB Ltd., 2019

[10] Hitachi ABB, Advanced services for transformers, https://www.hitachiabb-powergrids.com/offering/product-and-system/transformers/transformer-service/advanced-services-for-transformers