ETOS®

THE FUTURE OF POWER TRANSFORMER MANAGEMENT

ETOS® REPRESENTS A SYSTEMIC INNOVATION, SEAMLESSLY INTEGRATING EXISTING ACTUATORS, MODERN SENSORS, COMMUNICATION DEVICES, AND ALGORITHMS INTO A UNIFIED SYSTEM THAT ENCOMPASSES BOTH EDGE AND CLOUD COMPONENTS.

Photo: Maschinenfabrik Reinhausen

In the dynamic world of energy distribution, power transformers stand as the workhorses of the grid, silently converting electricity from one voltage level to another. While they play a crucial role in ensuring the smooth flow of power, these transformers face a myriad of challenges, including aging infrastructure, increasing demand, and the loss of skilled personnel. To address these challenges and maintain the reliability of power grids, energy network operators are increasingly turning to automation and artificial intelligence (AI) as powerful tools for optimizing transformer performance and reliability, as well as extending their lifespans.

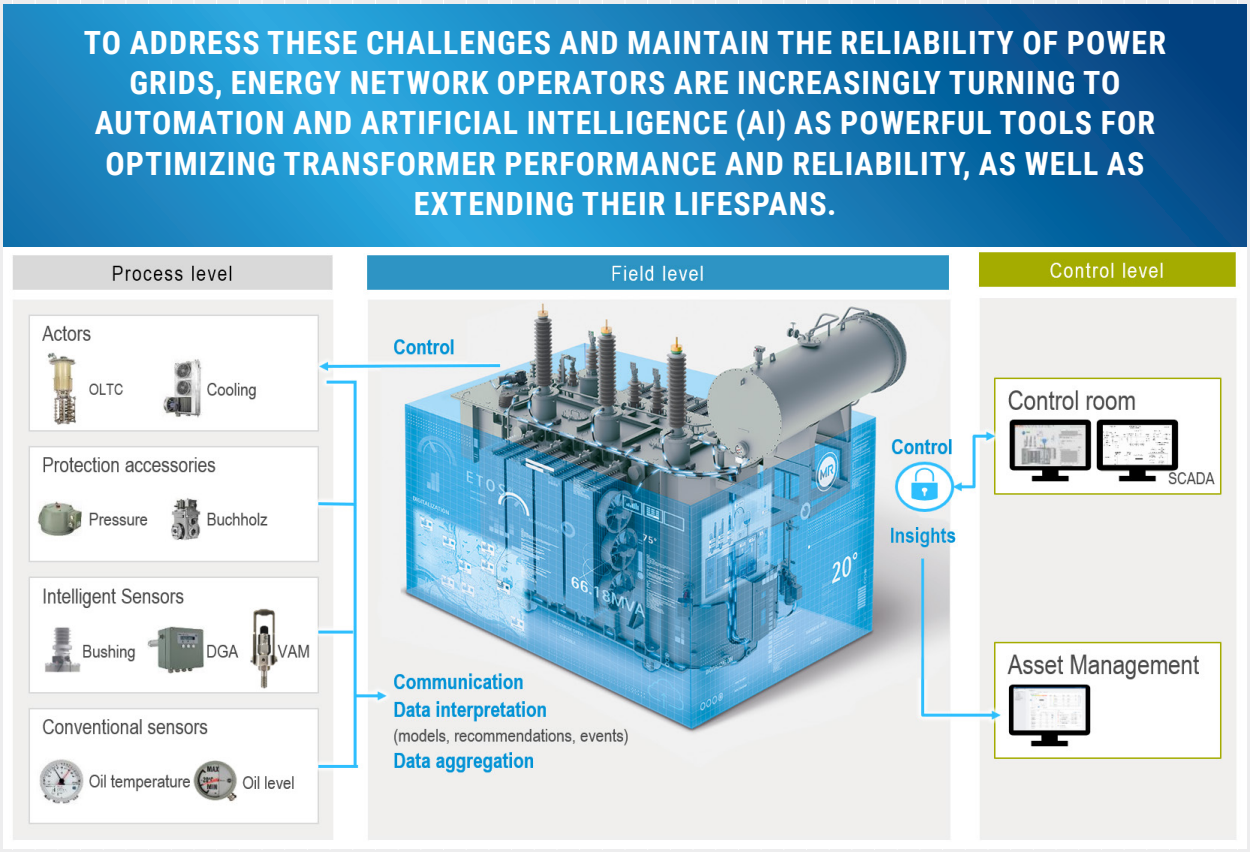


Figure 1: System overview

ETOS®: A Systemic Innovation for Power Transformer Management

At the forefront of this AI revolution is ETOS®, a pioneering solution developed by Maschinenfabrik Reinhausen (MR) that redefines the way power transformers are monitored, operated, and maintained. ETOS® represents a systemic innovation, seamlessly integrating existing actuators, modern sensors, communication devices, and algorithms into a unified system that encompasses both edge and cloud components. This intelligent infrastructure creates self-learning digital twins of network nodes, providing operators with unprecedented insights into the condition and performance of their transformers.

Figure 1 depicts a simplified representation of a power transformer's automation architecture, highlighting the three distinct levels: process, field, and control.

BY SEAMLESSLY INTEGRATING SENSORS, COMMUNICATION DEVICES, AND ADVANCED ALGORITHMS, ETOS® CREATES A DIGITAL TWIN OF THE TRANSFORMER. THIS DIGITAL TWIN SERVES AS A COMPREHENSIVE VIRTUAL REPRESENTATION OF THE TRANSFORMER'S CONDITION AND PERFORMANCE, PROVIDING OPERATORS WITH UNPRECEDENTED INSIGHTS INTO ITS HEALTH AND OPERATION.

Process Level:

At the heart of the power transformer lies the process level, encompassing the physical components that enable the conversion of electricity from one voltage level to another. On this level there are sensors (conventional and intelligent), protection accessories and actors (OLTC and cooling system). These are in physical contact with the transformer.

Field Level:

Acting as the bridge between the physical process and the control systems, the field level incorporates sensor information that monitor the transformer's condition and actuators that control its operation. ETOS® plays a vital role at this level, gathering data from various sensors and applying algorithms to analyze and interpret it as well as ensuring an efficient control of the temperature and the voltage. To suit different utility requirements, it supports the modular integration of functions in the areas of control, regulation, monitoring, and the tap-changer drive. By seamlessly integrating sensors, communication devices, and advanced algorithms, ETOS® creates a digital twin of the transformer. This digital twin serves as a comprehensive virtual representation of the transformer's condition and performance, providing operators with unprecedented insights into its health and operation. This holistic approach empowers operators to make informed decisions about maintenance schedules, optimization strategies, and overall asset management.

Control Level:

The control level forms the outermost layer of the power transformer's automation architecture, encompassing the software and hardware systems that manage the transformer's operation. It receives data from the field level, analyzes it, and sends commands to the actuators to ensure the transformer operates optimally. ETOS® acts as a bridge between the field level and control level, providing real-time insights and actionable recommendations to the control system (SCADA) and asset performance management systems.

Photo: Maschinenfabrik Reinhausen

Linking the dots with ETOS® Asset Intelligence

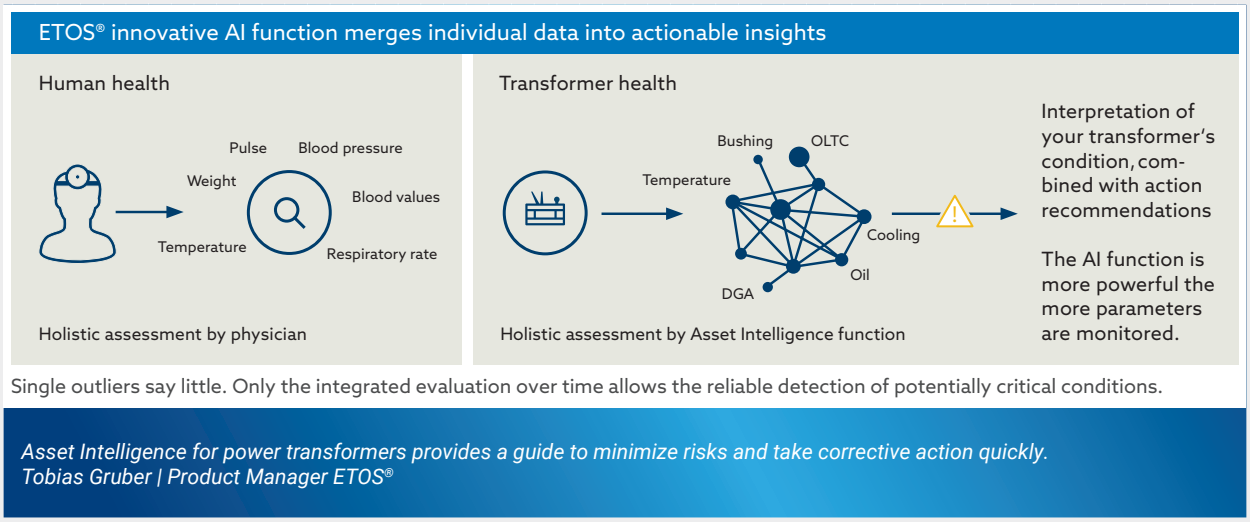
New technologies can help compensate for the loss of personnel knowledge and the increased demands on operating equipment.

Monitoring and sensor systems on power transformers, such as DGA systems, are often installed on power transformers for early fault detection. These can detect operating states and send corresponding messages when limit values are exceeded. However, just adding more sensors to a transformer has limited benefit. If the information sources aren't consolidated, the frequency of false alarms increases with the number of sensors, and failure diagnosis requires human intervention.

For example, if temperature, partial discharge and DGA sensors are all capable of detecting winding faults, their statements are not compared with each other. Thus, contradictory statements can occur, and a simple diagnosis is not possible. With ETOS® Asset Intelligence, all sensors present on the power transformer are integrated and considered together. A probability-based network checks which error patterns best match the warning messages that have occurred as well as those which have not occurred. In addition, the occurrence rates of typical transformer faults, as well as the false positive rates of sensors are taken into account.

The result is a probability estimate for all known transformer problems, with the most likely problems being displayed to the customer, along with a list of reasons for the findings. This allows the specialist to interpret the diagnostic results in a simplified and efficient way.

This approach mimics the way a human doctor diagnoses an illness by considering various symptoms and medical tests, ensuring that operators receive accurate and actionable insights.



ETOS® Asset Intelligence in Action

The following example serves as an illustration: The Buchholz relay has tripped, and the hydrogen level is greatly increased. Otherwise, there are no further limit violations. The corresponding diagnosis by ETOS® Asset Intelligence is shown below.

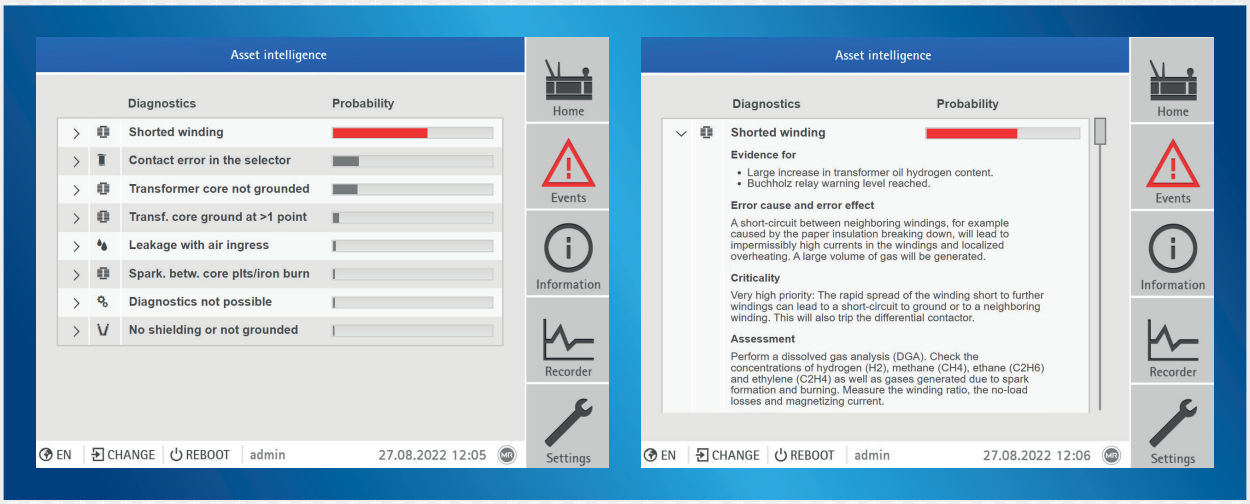


Figure 2: Example ETOS® Asset Intelligence

By using ETOS® Asset Intelligence, the operator gets not only data but qualified support which provides competent recommendations for actions.

Beyond Fault Diagnosis: A Holistic Approach to Asset Management

ETOS® Asset Intelligence goes beyond simply identifying faults; it provides a comprehensive assessment of the transformer's overall health. The system analyzes historical data and sensor readings to predict potential future faults, enabling proactive maintenance planning and preventing costly failures. This predictive capability allows operators to optimize maintenance schedules, extend transformer lifespans, and minimize downtime.

Compensating for Skilled Personnel Loss and Maximizing Efficiency

As the energy industry grapples with the retirement of experienced personnel, ETOS® Asset Intelligence steps in to bridge the skill gap. By automating fault diagnosis and providing actionable insights, the system empowers operators to make informed decisions independently, freeing up skilled personnel to focus on more complex and critical tasks. This automation not only enhances efficiency but also reduces the risk of human error.

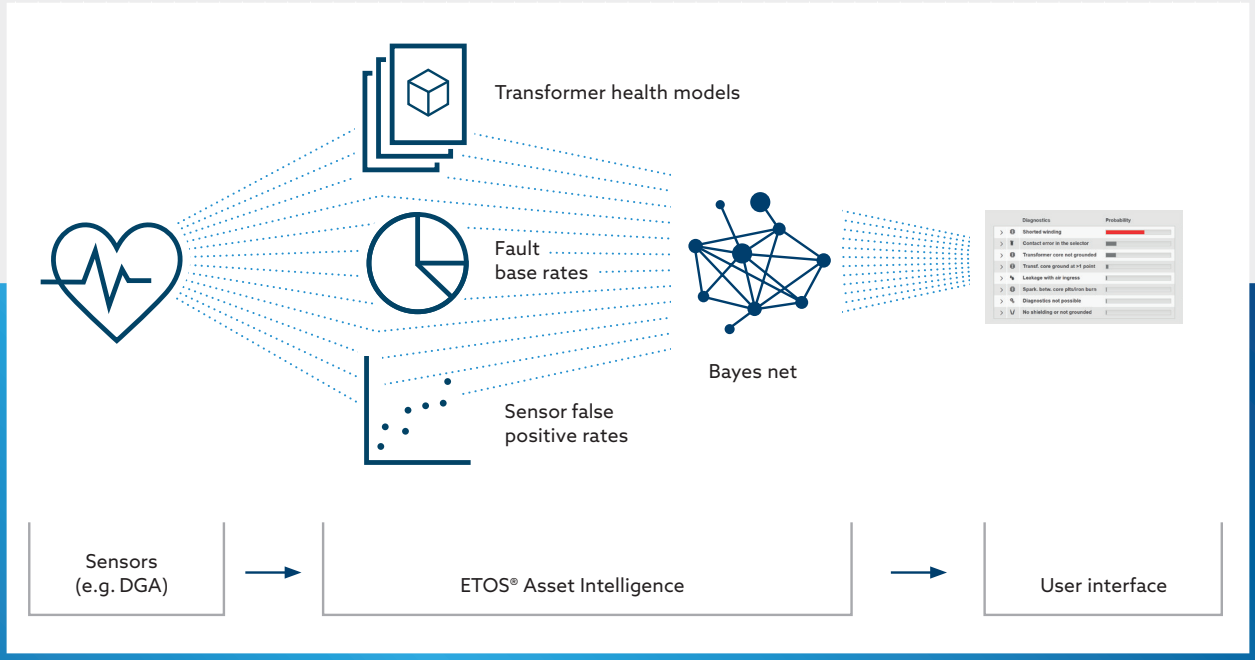


Figure 3: Function principle of ETOS® Asset Intelligence

ETOS®: A Catalyst for Sustainable Grid Operations

By harnessing the power of AI, ETOS® is revolutionizing the way power transformers are managed, leading to significant improvements in efficiency, reliability, and asset utilization. By extending transformer lifespans, reducing maintenance costs, and ensuring the smooth operation of power grids, ETOS® plays a crucial role in sustainable energy distribution. As AI continues to advance, ETOS® is poised to become an indispensable tool for maintaining the reliability and resilience of power grids worldwide.

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ETOS® ASSET INTELLIGENCE GOES BEYOND SIMPLY IDENTIFYING FAULTS; IT PROVIDES A COMPREHENSIVE ASSESSMENT OF THE TRANSFORMER'S OVERALL HEALTH. THE SYSTEM ANALYZES HISTORICAL DATA AND SENSOR READINGS TO PREDICT POTENTIAL FUTURE FAULTS, ENABLING PROACTIVE MAINTENANCE PLANNING AND PREVENTING COSTLY FAILURES.

Photo: Maschinenfabrik Reinhausen