An introduction to predictive maintenance for high voltage assets.

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Introduction

Predictive maintenance uses data-driven, proactive maintenance methods to analyse the condition of equipment, the aim being to predict when maintenance should be performed. Today, that means using data science and predictive analytics to assess when equipment is likely to fail, so that problems can be rectified before they reach a critical point and result in unscheduled downtime.

Predictive maintenance began to gain ground in the 1990s, when monitoring the condition of mechanical equipment through techniques such as vibration analysis started to be adopted. Other factors, such as heat, pressure, noise and lubricant condition, are also factors for machinery with moving parts. But what about power systems?

While voltages, currents, power, temperature and electromagnetic quantities have always been monitored, combined with regular surface inspection and material quality testing, the limitation of this approach is the inability to look forward into the future.[1] Ultimately, that means that the first time a problem becomes evident is often when the power system goes down. In the 2020s, with a raft of diagnostic technologies available, it's hard to disagree with the statement that running equipment to failure is an outdated approach.

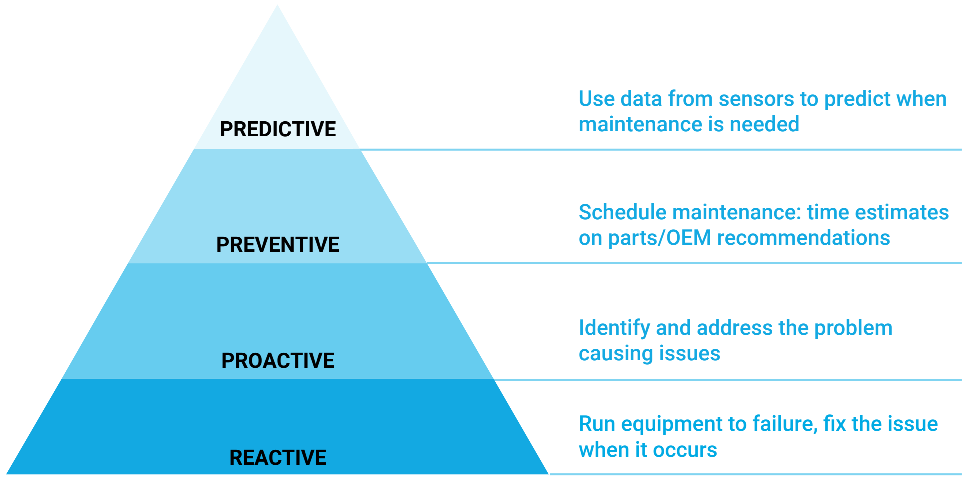
Essentially, predictive maintenance is all about getting to the heart of the root cause of any potential issues, predicting time to failure and maximising uptime. The clear advantage of predictive maintenance for high-voltage power systems is that catastrophic failure can be avoided, avoiding costly disruption, emergency maintenance and even loss of life.

In this concise ebook, you'll gain an understanding of predictive maintenance as a strategy for protecting high-voltage assets and how techniques and software have evolved to offer new actionable insights that can save time, money and, potentially, lives.

1 Condition-based predictive maintenance of industrial power systems, Mohammad Azam; Fang Tu; Krishna R. Pattipati, 2002, published in SPIE Proceedings Vol. 4733: Component and Systems Diagnostics, Prognostics, and Health Management II Peter K. Willett; Thiagalingam Kirubarajan, Editor(s)

Predictive maintenance (PdM): the starting point

To quickly breakdown approaches to maintenance, these can be divided into one of four categories: reactive, proactive, preventive and predictive – in effect, a hierarchy of maintenance. The traditional, now outdated, reactive approach sits at the bottom of the pyramid, and has been largely superseded by more insightful methods in many sectors.



"Periodic testing is certainly better than no testing, but it isn't perfect. Serious loss can occur if an undetected problem reaches catastrophic failure in the period between surveys. Obviously, if you test more frequently, the chance of failure goes down. However, at some point, that becomes too labour intensive and financially onerous.[2]"

While preventive maintenance brings many benefits over reactive maintenance and moves a step further on from a proactive approach, it is essentially inefficient, with the risk of personnel becoming 'busy fools' through arduous maintenance schedules. Stating the obvious, maintaining a safe, uninterrupted power supply is the critical priority for the energy sector. When the focus is purely on preventive maintenance, the reliance on carrying out regular checks and maintenance loses sight of that goal. Activity is focused on scheduled, calendar-based inspections that may be neither necessary nor timely. Moreover, these planned inspections may miss critical warning signs at the point when there is time to address them with minimal disruption.

In contrast, predictive maintenance is entirely directed. It uses a combination of equipment monitoring and data analysis tools and techniques to detect problems in processes and defects in equipment so that these can be put right in good time – before a catastrophic failure. To do so involves combining data from connected devices and machines with remote monitoring and predictive analysis, taking into account any automated maintenance orders.

Not all predictive maintenance has to be fully automated. For machinery, predictive maintenance can also be carried out manually through equipment checks using handheld vibration or audio sensors.

2 Continuous monitoring is on the rise: can you adapt, William Higinbotham, EA Technology LLC, NETAWORLD, Fall 2018Prognostics, and Health Management II Peter K. Willett; Thiagalingam Kirubarajan, Editor(s)

Investing in predictive maintenance

To gain a true picture of the cost-benefit gains to be made through the real-time monitoring of assets' condition and data using technology and software, there are several key factors to take into account:

Time spent maintaining equipment
Production hours lost to maintenance
The cost of spare parts and supplies
Collateral costs in the event of catastrophic failure

It's fair to say that the entire cost of installing a predictive maintenance system would quite possibly be less than the costs incurred by a catastrophic failure event. In fact, data from the U.S. Department of Energy indicates that predictive maintenance can generate an impressive potential return on investment of roughly ten times the cost, with a 25-30% reduction in maintenance costs, a decrease in breakdowns of 70-75% and a 35-45% reduction in downtime.[3]

In short, weighing up all the permutations of what could go wrong with any given HV asset, as well as the ability to replace equipment at the right time, the justification for preventive maintenance is not hard to demonstrate.

25-30%
REDUCTION IN MAINTENANCE

70-75%
DECREASE IN BREAKDOWNS

35-45%
REDUCTION IN DOWNTIME

3 Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency, G. P. Sullivan, R. Pugh, A. P. Melendez, W. D. Hunt, August 2010, Prepared by Pacific Northwest National Laboratory for the Federal Energy Management Program U.S. Department of Energy

Why predictive maintenance works

Predictive maintenance removes the guesswork. It's data-based and relies on continuous monitoring, which provides an accurate view of exactly what's taking place.

Creating a historic record of power quality to spot trends. This could be anything from a surge in the amount or seriousness of dips or a growth in harmonics. The resulting maintenance averts unscheduled shutdowns, which can bring significant financial benefits in keeping operations running.

Using data to plan ahead. Providing data to determine the loading of existing transformers, backup supplies and for planning future expansion. All of this is incredibly helpful in assessing the appropriateness of budget allocation for return on investment.

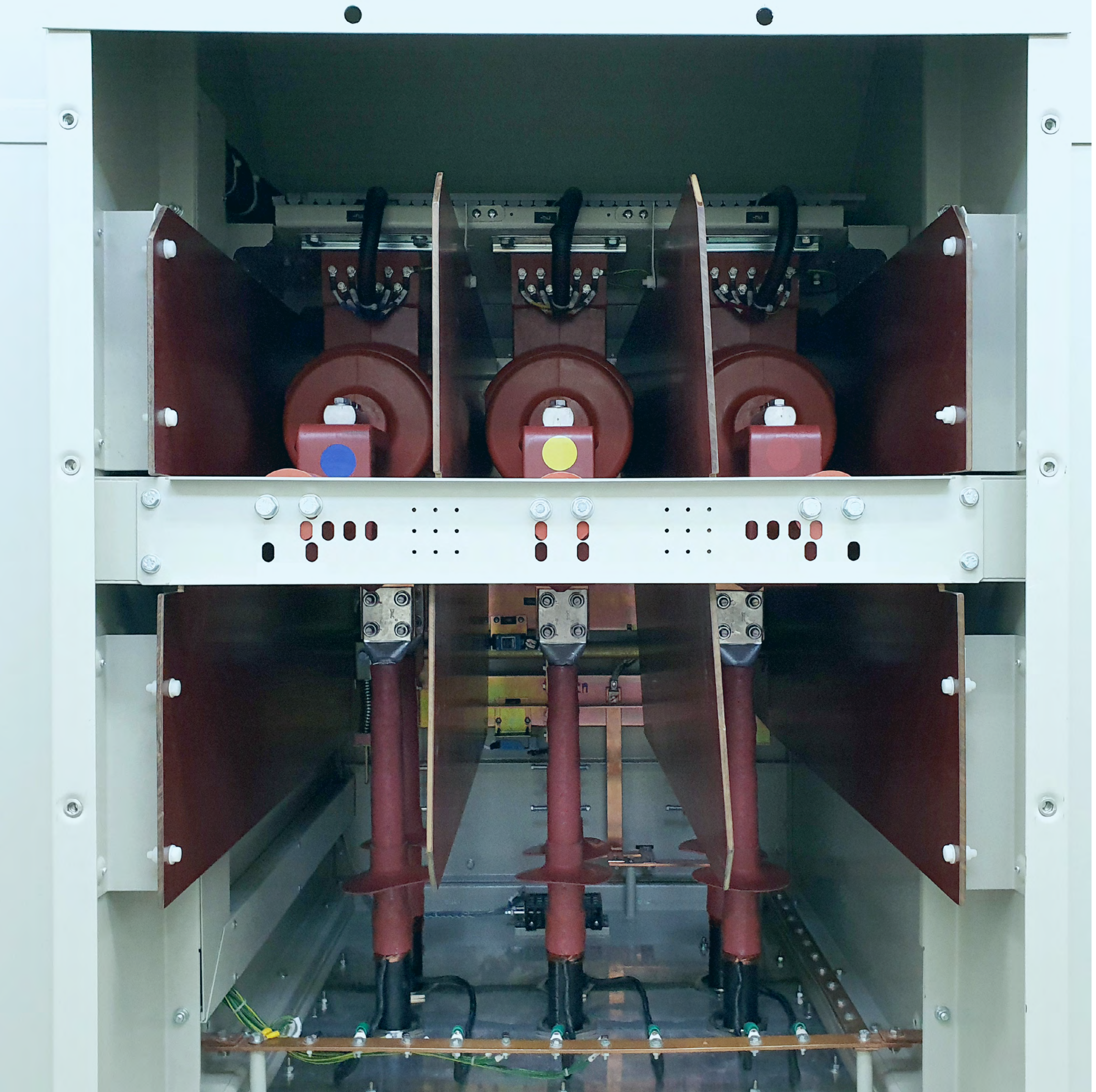
Optimal identification of problems. The right people can receive instant alerts as soon as a power problem occurs. Immediate action can isolate the issue and stop a knock-on effect that could put an entire facility or network at risk.

Continuous monitoring of Partial Discharge is essential. This serves to ensure detection of degradation to insulation that could cause premature failure of equipment such as switchgear and cables.

Understanding what went wrong. Continuous monitoring means that you have the data to unpick the causes of power disruptions. Knowing how and where problems happened is the first step in understanding how to manage the outcome and avoid a repetition.[4]

It's not just about preventing catastrophic failure. Using predictive maintenance technologies, power utilities and private network operators can discover which assets are underperforming. Operating staff can then understand the factors leading to abnormal operations and plan in maintenance to address the issues. Predictive maintenance is extremely efficient and enables resources to be directed to exactly where they can bring the most benefit.

4 Voltage Dips: Predictive Maintenance – The Key to Power Quality, European Copper Institute (ECI), David Bradley Rhopoint Systems Ltd March 2001 (Version 0b November 2001)



Predictive maintenance for HV assets

So how does all of this apply to high-voltage assets?

The consequences of failing to prevent high-voltage equipment malfunctions can be dire. Of course, replacing the equipment that has failed can be extremely costly. But the bigger picture is even more crucial: the domino effect of power outages in terms of downtime, inconvenience and hazards impacting the public and the environment can add up to an exponentially costly error if essential repairs are missed. The associated reputational damage, while hard to quantify, can be long lasting.

In an ageing network, directing maintenance in a very focused way can help to avoid the challenges of time-based preventive maintenance that relies on the availability of technicians. Collecting and entering data manually is limiting and lacks the speed needed to monitor asset health in real time.

EA Technology Astute HV Monitoring®: Learn more

What does predictive maintenance for HV assets look like?

A high voltage monitoring system can utilise remote monitoring of HV assets. Breaking it down simply, these are some of the main components involved in predictive maintenance for high voltage assets:

Partial discharge (PD) monitoring

Left unaddressed, partial discharge can erode solid insulation, and the eventual outcome can be breakdown and failure. PD monitoring assesses the health of your insulation, replacing periodic PD surveys.

Signal analysis of the partial discharge activity measured includes localisation, trending and interpretation of suspicious spikes. In partial discharge testing, sensors pinpoint voltage stresses caused by the system voltage on deteriorated insulation components. Deteriorated insulation produces signals with partial discharge characteristics.

PD sensors pick up on these small electrical signals or discharges in or on the surface of the electrical asset's insulation.

HV system component monitoring

Whether monitoring is continuous or scheduled, components under scrutiny should comprise:

Cable systems, including cables, joints and terminations, underground cables and overhead lines. Monitoring should look for partial discharge in the cable network.

Switchgear, open and closed cells, air- or gas-insulated switchgear (AIS and GIS) installations.

Current and voltage transformers, connections and bushings.

In all cases, forewarning via a predictive system allows the time to plan the most efficient repair shutdown, ensuring the safety of both staff and physical assets.

Predictive maintenance for HV assets in action

Online monitoring of high voltage apparatus is a vital feature of a comprehensive predictive maintenance program. When a predictive maintenance approach is fully implemented, the care of connected assets – whether that be wind farms, substations or pumps, for example – is managed by the computerised maintenance management system (CMMS).

While it's possible to create piecemeal solutions by monitoring individual assets, it's important to remember that there are far greater advantages to taking a holistic approach to creating an integrated system.

Condition monitoring based maintenance

As predictive maintenance evolves, condition monitoring based maintenance (CDM) offers even deeper insights, dealing with the entire system as a complete entity. This moves predictive maintenance away from a 'mix-and-match' approach, allowing the full power of an integrated system to uncover risks that, left to human identification, might otherwise go undetected.[7]

7 Maintenance Management of Electrical Equipment (Condition Monitoring Based), Ashok Parikh, August 2014, Electrical Engineering Portal

"The greatest benefits of predictive maintenance are realised when multiple monitoring instruments are placed at various critical locations on the electrical infrastructure to continuously monitor power.[6]"

6 D. Bradley, "Applying predictive maintenance to power quality," 2001 Twenty-Third International Telecommunications Energy Conference INTELEC 2001, Edinburgh, UK, 2001, pp. 229-237.

Conclusion

Embedded predictive maintenance solutions secure and improve end users' electricity supply by enhancing the reliability of high voltage assets, including substations. Using a combination of mathematical, logical and statistical analysis, it's possible to monitor site performance remotely, detect faults and alert users about required performance improvements. The result: minimised downtime and optimal repairs through preempting asset failure, increased safety and the avoidance of catastrophic failures. Whether you are in the early stages of implementing predictive maintenance in a private network or exploring the whole-life costs of an integrated system, the investment involved in predictive maintenance for HV assets is more than offset by the many gains.

Safer, Stronger, Smarter Networks

EA Technology Limited
Capenhurst Technology Park
Capenhurst, Chester CH1 6ES

t +44 (0) 151 339 4181
e sales@eatechnology.com
www.eatechnology.com