MARKET DYNAMICS IN POWER TRANSFORMER MONITORING APPLICATIONS

Introduction

Power transformers are essential for the generation, transmission and distribution of electricity across the grid. As such, large power transformers are built to operate for decades without replacement and play a critical role in enabling utilities to deliver a continuous flow of electricity to their customers.

If a power transformer fails, the results can be catastrophic. The financial impact of a transformer failure and subsequent power outage can reach tens of millions of dollars – not to mention reputation damage and even loss of lives.

Due to ever-increasing energy consumption, an aging grid infrastructure and the growing use of renewable and distributed energy resources, stress on transformers is reaching potentially dangerous levels. Not only are transformers operating at a higher capacity for longer durations, they are also experiencing more volatile fluctuations in demand than in the past.

To avoid catastrophic transformer failure and minimize operational risk, power utilities are taking advantage of condition-based maintenance (CBM) and other proactive measures to improve the effectiveness of their transformer health management. Advanced monitoring and diagnostic tools, such as online DGA sensors, can help utilities identify impending failures and prevent costly outages.

By enabling predictive maintenance, online DGA platforms can help you reduce operational risks and raise the level and reliability of service provided to customers. At the same time, they help to optimize transformer efficiency, lower maintenance costs and extend the lifetime of mission-critical transformers.

Referring to the March 2017 deployment of such a transformer health monitoring system at a New York Power Authority (NYPA) power plant, Richard Kauffman, New York State Chairman of Energy and Finance said, “This innovation is a game-changer in power monitoring and problem diagnosis, and is yet another example of [our] strategy to make our power system both cleaner and cheaper for New Yorkers.”

Surveying the North American Transformer Monitoring Market

To better understand utilities' current transformer health monitoring practices, as well as their plans and priorities for the future, mPrest conducted a survey of leading North American generation power utilities. More than 20 utility and generation asset owners participated in this survey, operating a total fleet of over 7,500 large power transformers (both substation units and generation step-up (GSU) installations) that represents a significant sample of the North American market.

The survey results provide a clear picture of utilities' current transformer health monitoring activities, as well as offering insight into the most important factors driving the transition to real-time online DGA monitoring. Topics covered include the use of online versus offline DGA testing, considerations for migrating to online DGA, migration strategies and budgets for online DGA.

A sampling of survey questions and aggregated responses can be found in the appendix.

Key Findings

The survey clearly shows that power utilities understand the need for improved transformer health monitoring and have begun to implement online DGA monitoring and analytics to address this need. Ninety-four (94) percent of the survey respondents agreed with the statement: "It is important to implement online health monitoring for power transformers."

Below are several key findings related to the drivers, levels of adoption and spending outlooks for online DGA tools.

Online vs. Offline DGA Monitoring

Approximately 25% of the installed large power substation transformers in the study base were being monitored using an online DGA or other health monitoring unit/device.

For GSU transformer installations, the rate of online DGA monitoring was double the installed base rate noted among substation transformers, reaching about 50% on average. We also found that the use of analytics software in conjunction with online DGA monitoring is more prevalent for GSU transformers than that observed for substation transformers.

Thus, while many utilities in the study have begun to adopt online DGA tools, the majority of utilities continue to use "offline DGA testing services" for at least some portion of the installed fleet of transformers.

Aging Transformer Fleet

It is no secret that the large power transformer fleet in North America is aging, and our survey group reflected this fact. On average, 48% of all substation transformer installations at these utilities were between 20-40 years old, while 24% were more than 40 years old.

More importantly, 31% of respondents ranked age as a "most important factor" when it comes to determining whether to install an online health monitoring system on a specific transformer.

With respect to the GSU transformer fleet, respondents commented that the older the power plant and its related transformers, the more likely that the transformer fleet was to be equipped with online DGA monitoring equipment.

Other Drivers for Online Health Monitoring

Among the other factors that help determine the need for installation of an online health monitoring unit, several utilities ranked “the possibility of insurance savings versus the cost of a monitoring system” as high in importance. By substantially reducing the risk of a transformer failure, installation of an online monitoring system could translate into insurance savings that would help to offset the cost of the monitoring system. “Having a known component issue/failure history” was also viewed by many respondents as being a very important factor for installing an online health monitoring system.

Key Advantages of Online DGA and Analytics

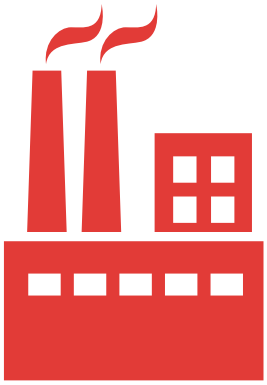
Modern utilities are aware of the limitations of traditional offline DGA testing, based on semi-annual samplings of transformer oil sent to a lab for analysis. In light of the growing challenges to transformer health, utilities require real-time situational awareness which cannot be delivered by traditional offline DGA methods.

Online DGA sensors, which take periodic (e.g., every 30 or even 15 minutes) samples and provide real-time results, help operational teams address these challenges. However, to fully leverage the data these sensors provide and to get a complete picture of transformer health, utilities should integrate additional sensors and manage the process using an intelligent and comprehensive online DGA platform. Examples of additional sensors that complement online DGA sensors include online bushing monitoring, IR camera (heat), tank vibration, tank temperature, partial discharge, geo-magnetic induced currents, acoustic emission and radio frequency interference (RFI). By collecting and performing advanced analytics on all of this information, utilities can gain valuable insight into transformer health.

Standards-based DGA platforms measure each sample in a standalone manner against a pre-defined threshold. The downside of these “snapshots” is that you don’t get the historical context needed to detect trends and patterns, as well as deviations from these patterns over time. This makes it difficult to predict what will happen in the near future (e.g., in one month’s time).

Advanced online DGA software products, on the other hand, offer utilities the following key advantages:

- Sub-threshold abnormality detection - Analyze both real-time and historical data to identify trends and then abnormalities even if the DGA level doesn’t exceed the standard-defined threshold. By collecting samples on an ongoing basis, you can monitor behavior over time and identify suspicious trend changes in direction between thresholds that standards-based analysis cannot detect.
- Predictive maintenance - Connect the dots, identify trends and predict situations where DGA levels are likely to cross a threshold in the near future. This enables early warning of potentially dangerous situations that warrant immediate maintenance actions.
- Recommended action – After predicting a potential problem, these platforms can also provide you with timely recommendations for specific maintenance activities to optimize transformer operations.



Moreover, implementing online DGA as part of a CBM program, together with Fleet Management, can create major savings on maintenance costs by ensuring that you do the right maintenance activities on the right transformers at the right time, rather than indiscriminately performing all activities on all transformers.

Prevalence of Online DGA Monitoring and Analytics Capabilities

Among those respondents that have already implemented online DGA sensors on some of their transformers, 60% are currently using a software application in conjunction with the online DGA sensors for advanced monitoring and analytics.

About one-third of the survey group indicated they currently have some level of insight or capability to detect sub-threshold abnormalities (i.e., detection of trend line abnormalities that enable earlier detection than threshold-based analysis). Overall, a majority of respondents indicated “an interest” in this important capability.

Of those respondents not using a software application, two-thirds cited plans to implement a software capability related to online DGA monitoring over the next 24-36 months.

Spending Outlook

The outlook for spending on transformer health monitoring solutions over the next three years shows gradual year-over-year increases, with a planned spending increase of 6% between 2017 and 2019.

Respondents estimated that about 21% of the total transformer health monitoring budget is/will be allocated for DGA analytics software.

This budget outlook reflects the fact that the transition to online DGA monitoring is not going to happen overnight. All utilities still perform offline DGA testing as part of their transformer maintenance activities. Those already using online DGA monitoring for some of their transformers continue to use offline DGA for the rest. Accordingly, transformer health monitoring solutions that can support both online and offline DGA will be instrumental during the transition phase.

Conclusion

In light of our findings, it is clear that the power utility market sees value in real-time online DGA solutions as a way to enhance the effectiveness of large transformer health monitoring activities, reduce power outages and improve power supply service to consumers.

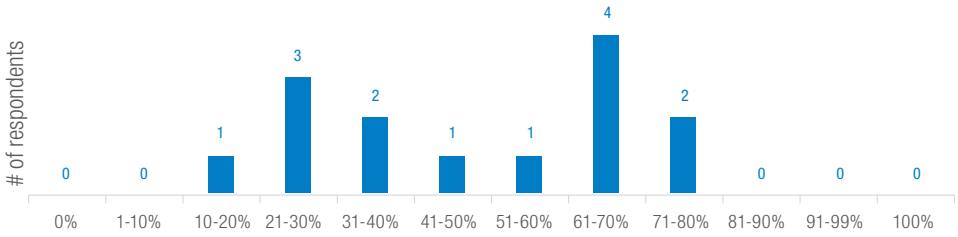
The transition from offline to real-time online DGA systems is already underway, being driven by an aging transformer fleet, the need to reduce the risk of transformer failure and the need for real-time situational awareness.

Recently developed technologies enable and increase the value of migrating to online DGA. Online DGA monitoring and analysis generates insights into transformer health that offline systems simply can’t deliver, particularly with respect to sub-threshold abnormality detection and predictive maintenance.

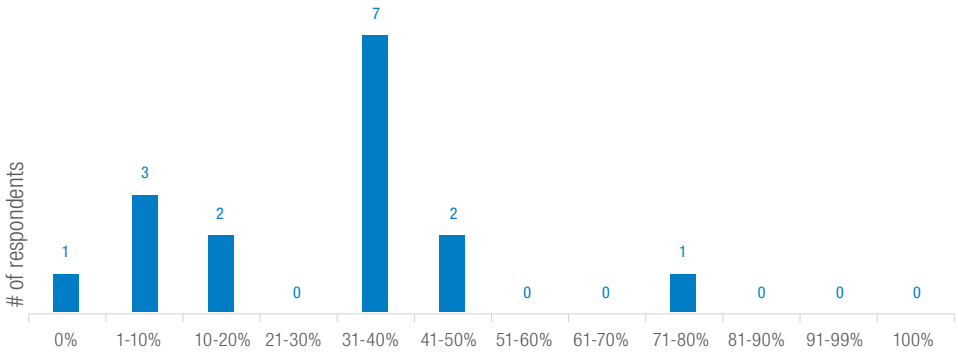
Since utilities are migrating their transformer fleets to online DGA in a gradual manner, it is important that monitoring and analysis solutions support both online and offline DGA simultaneously. Moreover, in order to enable utilities to leverage new sensors and new technologies as they become available, transformer monitoring solutions should be vendor-agnostic for maximum flexibility and adaptability.

Appendix – Survey Details

Approximately what percent of your substation power transformer fleet (72.5kV and above) is between 20 - 40 years old?



Approximately what percent of your substation power transformer fleet (72.5kV and above) is older than 40 years?



Approximately what percent of your substation power transformers is monitored by an online-DGA health monitoring system?

The average percent of substation power transformers being monitored by an online-DGA health monitoring system was about one quarter of the total fleet (23-26%).

Which factors help your utility determine whether to install a health monitoring system on a specific transformer? Please rank these factors from 1 to 8, with 1 being "most important" and 8 "least important." A ranking may be used more than once.

Average ranking of factors: 1 = "most important"

Age	MVA	Cost	High Side Voltage	Provides service to critical customer(s)	Having a known component issue/ failure history	Insurance savings vs. cost of a monitoring system	Other
4	3	4	3	3	4	6	5

What percentage of these GSU transformers have a transformer health monitoring system installed?

The 10 responding utilities that have GSU transformers have on average 50% of their GSU fleet now operating with a transformer health monitoring system. Three respondents indicated 90%-100% of their GSU transformers have health monitoring, while four respondents indicated 0%-25% have it.

What technologies do you currently use to monitor the health of substation power transformers? Check all that apply.

Note the mix of responses that indicate the use of off-line DGA services in at least some portion of power transformer fleets in addition to any online monitoring installations – which typically are limited to about one quarter of the fleet.

Number of Respondents out of 16 total

	On-line DGA (Alarm only- no analytic software)	On-line DGA (with analytic software)	Off-line DGA	On-line Insulation Resistance	On-line bushing monitoring	Other
72.5kV	3	1	8	0	1	3
123-145kV	8	2	10	0	2	1
170kV	6	0	6	0	0	2
245kV	6	4	6	0	5	2
362kV	3	1	2	0	1	0
550kV	4	2	5	0	4	2
800kV	0	0	1	0	0	0

What technologies do you currently use to monitor the health of generation (GSU) power transformers? Check all that apply.

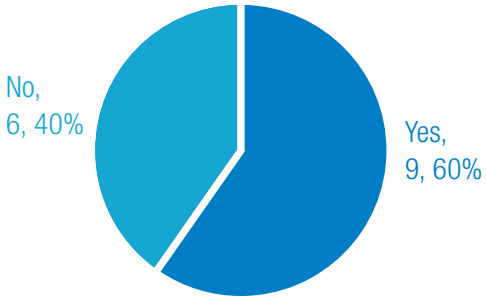
In the table below, note the importance of on-line DGA having some analytics software. Also the role played by off-line DGA remains important.

Out of 10 respondents who have generation assets or GSU transformers

	On-line DGA (Alarm only- no analytic software)	On-line DGA (with analytic software)	Off-line DGA	On-line Insulation Resistance	On-line bushing monitoring	Other
72.5kV	1	1	4	0	0	0
123-145kV	3	3	6	0	1	1
170kV	1	1	4	0	0	0
245kV	3	5	6	0	3	1
362kV	3	0	1	0	0	0
550kV	2	2	3	0	2	1
800kV	0	0	1	0	0	0

Are you currently using a software application to monitor on-line DGA sensors?

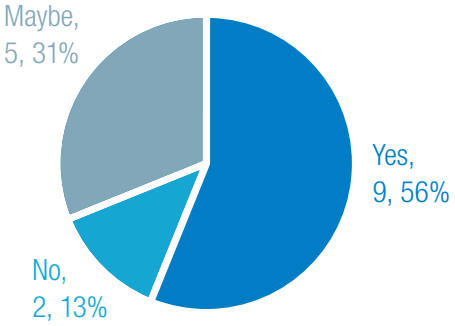
There were nine users of software applications (analytics) being used in conjunction with on-line DGA instruments. Six other respondents indicated no use of analytics software related to their use of DGA instruments.



(One did not answer)

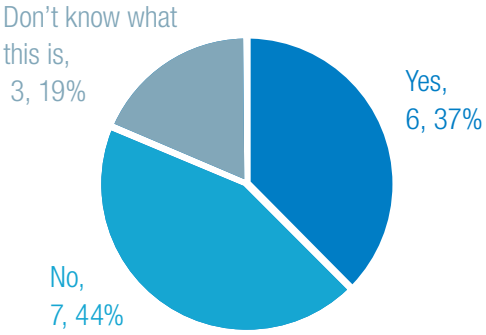
Are you interested in this capability?

Importantly a majority of respondents did indicate an interest (combining Yes and Maybe responses) to continuous monitoring of sub-threshold abnormality detection.



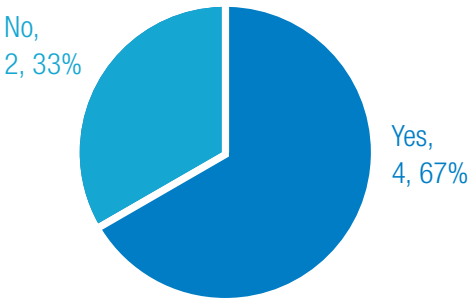
Are you currently able or interested to continuously monitor sub-threshold abnormality detection (i.e. detection of trend lines abnormalities, enabling a much earlier detection than threshold-based analysis)?

About one-third of the survey group indicated having any insight or capability to monitor sub-threshold abnormality detection at the time of the survey.



If you are not using a software application to monitor on-line DGA sensors, are you planning to use one in the next 2-3 years?

Four of six respondents not currently using analytics to support their DGA installations indicated plans to have such a capability within the next few years.



About mPrest

mPrest is a global provider of mission-critical monitoring, control and big data analytics software. Leveraging the power of the Industrial IoT, mPrest's integrative "system of systems" is a proven catalyst for digital business transformation. Our management solution has been deployed in next-gen IoE (Internet of Energy) applications for power utilities, as well as innovative management applications for water utilities, smart cities, defense and HLS.

By connecting the dots across multiple disciplines, mPrest delivers unified situational awareness, sophisticated analytics, end-to-end IT/OT integration and process management. Featuring unprecedented interoperability and real-time data optimization, mPrest allows organizations to accelerate time-to-market, improve system performance and reduce operational costs.

For more information, visit us at www.mprest.com

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