Using Predictive Analytics to Optimize Asset Maintenance in the Utilities Industry

By working proactively to collect and distill digital information, transmission and distribution utilities can enhance customer satisfaction, reduce total cost of ownership, optimize the field force and improve compliance.

Executive Summary

Aging assets, an aging workforce, the introduction of networked smart grids and a proliferation of intelligent devices on the power grid are challenging utilities to find more effective and efficient ways to maintain and monitor their critical assets — and to do so with high availability and reliability.

The ultimate objective of traditional or smart asset management is to help reduce/minimize/optimize asset lifecycle costs across all phases, from asset investment planning, network design, procurement, installation and commissioning, operation and maintenance through decommissioning and disposal/replacement.

Optimizing the costs associated with each of these lifecycle phases remains among the key objectives of an asset-intensive utility organization. Sadly, preventive maintenance schedules prescribed by manufacturers haven’t really helped utilities to avoid asset failures. Many utilities have realized that avoiding unexpected outages, managing asset risks and maintaining assets before failure strikes are critical goals to improve customer satisfaction.

A recent survey1 across 200 global utilities suggests that in the area of power distribution, reducing outages and shortening restoration times are the most significant challenges. Approximately 58% of surveyed utilities said they need a mechanism for predicting equipment failure.

These challenges have forced utilities to leverage analytics to extend the life of assets and bring more predictability to their performance and health, which ultimately helps them plan and prioritize maintenance activities.

Predictive analytics is a process of using statistical and data mining techniques to analyze historic and current data sets, create rules and predictive models and predict future events. This white paper examines how transmission and distribution (T&D) utilities can effectively apply predictive analytics to smart asset management to realize asset lifecycle cost reduction and improve the accuracy of their decision-making. Three meaningful types of predictive analytics benefits have been identified:

- **Technology:** The amount of money saved on technology or technology costs avoided by introducing the analytic solution.
- **Productivity:** Efficiency savings due to the reduced amount of time and effort required for particular tasks.
• **Business process enhancement**: All identifiable annual savings that were realized due to changes in business process supported by the analytic application.

The Business Case for Predictive Asset Analytics

As Figure 1 illustrates, predictive asset analytics can be counted on to help T&D utilities achieve the following objectives:

• **Improved customer satisfaction and reliability of power**: Customer satisfaction and power reliability are two important measures of a utility’s performance. Unexpected equipment failures impact both measures. Customers expect planned outages to be communicated in advance to plan their electricity consumption. Utilities are also under pressure from strict outage regulations to proactively maintain their assets before failure to avoid penalties. The reliability metrics that U.S. utilities must report to regulatory authorities include:
  > **SAIDI**: The minutes of sustained outages per customer per year.
  > **SAIFI**: The number of sustained outages per customer per year.
  > **MAIFI**: The number of momentary outages per customer per year.

• **Reduced total cost of ownership by prioritizing maintenance activities**: Each asset has multiple associated costs – primarily related to procurement, installation, operations and maintenance, failure and decommissioning. Unexpected failure cost is the leading expense component of any asset. Failure cost includes the expense of the asset in service, collateral damage cost, regulatory penalty, disposal of damaged asset, lost revenue, intangible costs, etc. Thus, utilities can save a significant amount of money by avoiding key equipment failure. Predictive maintenance practices utilize historical data from multiple sources to build accurate, testable predictive models, which allows us to generate predictions and risk scores. Modeling techniques produce interpretable information allowing personnel to understand the implications of events, enabling them to take action based on these implications.

• **Better route planning and optimization of field crews**: A clear understanding of asset health can help utilities in work planning, prioritization and scheduling. Unexpected equipment failure often requires reallocation of crews from other work locations to restore the outage, hiring of extra labor and contractors and, often, a complete rescheduling of other planned maintenance activities. The percentage of work from reactive activities, in our view, can be effectively used for predictive maintenance, thus improving crew response time and utilization and reducing total maintenance duration and asset down time.
• Improvement on overall safety and compliance: Predictive asset analytics will proactively address potential safety risks. By integrating data from multiple sources – SCADA, EAM-GIS, online monitoring systems, weather channels along with nonoperational data (vendor provided operational rules, equipment data sheets, industry standards, etc.) – utilities can quickly identify safety risks and take suitable operation actions to mitigate them.

Predictive Asset Analytics Implementation Challenges

As utilities embrace predictive analytics to enhance asset management, they need to come to grips with the following issues:

• Data management: The shift to a predictive analytics solution brings multiple challenges in data management. These include:
  
  > Data quality: Predictive analytics solutions are intended to collect data across internal systems such as EAM, SCADA, Historian and online monitoring systems. The common issues seen include duplicate data, different time stamps in multiple systems for the same data and conflicting information in multiple systems. Poor data quality results in bad analysis and recommendations.
  
  > Data to look for: Subject matter experts need to define input data requirements for solutions. Identification of critical data points and exclusion of less relevant data items are essential before going ahead with predictive analytics.
  
  > Integrated data collection: The existence of multiple data silos is another problem. Utilities use multiple systems such as SCADA, EAM, online monitoring, etc., which often do not easily communicate with one another. A predictive solution should be able to integrate legacy systems and new systems such as GIS, weather and events systems to build accurate, testable predictive models.
  
  > Dealing with large data sizes: Traditional legacy systems are not designed for handling today’s volume of data needed for predictive analysis (e.g., terabytes of data). Depending on the scope of the solution, a utility should create an approach for managing data or adopt a big data platform for managing the data.

• Choosing the right technology platform: The appropriate choice of platform typically depends on application scope, such as use cases and response times, the volume and variety of data, the existing systems environment and extensibility to accommodate future needs. The platform should be able to handle both unstructured and structured data including events, time series and metadata.

Advanced computing capabilities such as in-memory processing and 3-D storage are also required for providing services such as search-query-aggregate on the go. For advanced analytics, the platform should be capable of integrating with third-party statistical and modeling tools, such as R and SAS, as well as real-time event processing to apply these models and logic to identify root causes and predict failures before they happen.

• Uncertainty in implementation cost and ROI: The ROI models for predictive asset solutions are often complex and are not generic for all assets. Predictive asset analytics is about maximizing asset utilization while minimizing unexpected failures, Cap-Ex and Op-Ex. However, failure avoidance can lead to additional maintenance work on the asset. Thus, any reduction in failure cost will lead to increases in maintenance costs. Predictive maintenance also brings savings in work management by diverting reactive maintenance workloads to planned maintenance. By thus increasing the efficiency of maintenance schedules, costs and resources, it results in fewer outages and higher customer satisfaction.

Predictive Asset Analytics: One Solution

Once the utility has selected critical assets that should be placed under predictive maintenance, we suggest the following approach.

• Define contributing parameters. A business SME-guided approach is better than a purely data-driven approach. The first step is to define the input variables for analysis. Most of the contributing parameters to asset failure are known to the SME. Statistical analytics can add value by improving rules, as well as identifying and bringing more variables under monitoring and analysis.

• Create known domain rules. Condition monitoring rules are based on known relation-
ships between the contributing variables and the failure event. In addition to known rules, custom action rules can be configured to trigger automatic work orders.

- **Create unknown rules based on analytics.** Analyze holistic historical asset failure information from SCADA/Historian, EAM systems, weather feeds and online monitoring systems to gain insights into failures. Given the multitude of statistical analysis methods available, the utility must carefully evaluate the solution objectives and data elements to make an informed choice. After analysis, create new prediction rules based on insights, assign risk levels and automate work order actions.

Key solution components include:

- **An operations dashboard:** Business users will appreciate a GIS-enabled, intuitive summary dashboard with quick summary of alerts and work orders.

- **An asset model:** A statistical module is required to analyze the historic event information and to create an asset model. Real-time information will be compared with the reference asset model to predict the failure event.

- **Rules setup:** Organizations must provide an intuitive interface to help users pull information from multiple systems and configure known alerts and actions rules for meaningful asset management. The same functionality can be used to configure alerts and actions rules based on statistical analysis, taken from the asset model.

- **Prediction notification:** A summary view of recent notifications in the main screen can easily attract the utility operator’s attention, thus enabling him to act quickly to avoid failures. A detailed view of predictive alerts will help the utility operator to explore the nature of alerts in detail and make informed decisions. The EAM system should be integrated with a predictive system; this enables the user to view asset-specific work-order status and trigger new work orders directly from the predictive solution, based on predictive alerts.

A conceptual solution architecture is illustrated in Figure 2. The contributing parameter data (real-time and history) is collated from multiple systems and managed by a big data server, which has high availability and fault tolerance capabilities and is equipped to handle a large volume and variety of data. External systems such as EAM and GIS are integrated with the applications server. The core part of this environment is the analytics engine, which can either be part of the platform.

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**Anatomy of a Predictive Analytics Asset Management Environment**

![Diagram](image.png)

*Figure 2*
or integrated via a third-party component. An ideal solution should support desktop and mobile interfaces, with solution components such as an operations dashboard, predictive notifications, asset models and predictive rules engine.

Looking Forward
As organizations move forward on their predictive analytics journeys, we recommend the following:

• **Tightly define the business need, future requirements and solution extensibility.** Utilities need to ensure that a predictive asset analytics solution fits into their overall business strategy and future business requirements. We suggest utilities decide on three elements: define the immediate objectives of the solution; understand future business requirements; and assess the extensibility requirements to support additional applications. Once these aspects are known, the analytics platform and statistical method for the solution will more easily follow.

• **Improve process and upgrade IT infrastructure.** Most utilities may not have the right processes and data needed to support analytics solutions. Therefore, it is imperative to improve business processes and upgrade IT infrastructure to support any analytics solution before it is deployed. A utility can choose to follow a step-wise approach where it first implements the analytics capability, addressing existing process and infrastructure needs, and then gradually rolls out advanced analytics functionalities to fit with ongoing process improvement and IT system upgrades.

• **Embrace a data-driven culture.** Presently, most utilities follow a person-centric approach. They completely rely on the experience of their engineers. Given the industry’s aging workforce, the time has come to adopt a data-driven culture to reinforce its viability as many SMEs retire or leave the workforce.

• **Team play is needed among players to succeed in implementation.** Implementation quality is an important issue that prevents utilities from achieving projected results from predictive analytics programs. Very few solution providers have an end-to-end capability to implement predictive solutions. To mitigate the implementation risk, utilities should involve multiple providers and encourage “team play.” This strategy will bring best-in-class in solution components provided by various expert players in data management, systems integration, analytics engines and operational technology integration.

• **Have you calculated your returns correctly?** Calculating ROI for predictive analytics is difficult. While many of the benefits, such as better communication and improved knowledge, are intangible, an effort should be made to quantify the benefits of a better operational decision. Due care must be given and include scenario analysis; direct and indirect impact on cost and revenue components; improved process benefits; and related synergies derived from predictive asset solutions. Rather than implementing only “must have” functionalities in the solution, utilities should carry out cost-benefit analyses that include the deployment of “must haves,” “should haves” and “may haves,” and understand the complete benefits before deciding on the scope of the solution. Experience shows that the addition of more functionality – thereby extending the program scope – can significantly increase ROI in the long term.

Footnote

1 Ventyx Electric Utility Executive Insights Annual Survey Results, 2013.
About the Authors

Quang Nguyen is a Consulting Director within Cognizant Business Consulting’s Energy and Utilities Practice. He has over 15 years of consulting experience, 10 of which were spent in manufacturing. Quang has experience in smart grid initiatives, including EE/DR programs, assets management, security, customer portals, SAP CRM, GIS, HAN, smart meter network operations, alerts and notifications, OMS, data governance, customer/operations analytics and rate calculation engines. He holds a B.A. in chemical engineering from Case Western Reserve University, an M.S. in applied math and statistics from Rochester Institute of Technology and an M.B.A. from University of Rochester. He can be reached at Quang.Nguyen2@cognizant.com.

Sachin Kumar is a Senior Manager of Consulting within Cognizant Business Consulting’s Energy and Utilities Practice. He has 18-plus years of global energy and utilities experience in consulting and business operations and has led consulting engagements with several large global energy utility companies. Sachin is also responsible for developing Cognizant’s utilities industry solutions, with a focus on the T&D segment. He is a certified energy manager and auditor and has a degree in electrical engineering and a post-graduate certification in general management. He can be reached at Sachin-I2.Kumar-I2@cognizant.com.

Girish K.G is a Senior Consultant within Cognizant Business Consulting’s Energy and Utilities Practice. He has more than seven years of global energy and utilities experience in consulting as well as plant operations and maintenance. Girish has been in client-facing lead roles in multiple consulting engagements, where he has offered counsel on process transformation and business requirements. He has strong experience in asset management, work management, retail and C&I billing, complex pricing and product management. Girish holds a post-graduate degree in management from Indian Institute of Management. He can be reached at Girish.KG@cognizant.com.

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