AVEVA

August 2021

WHITEPAPER

Data infrastructure solutions for utilities today and tomorrow

Executive summary:

As grid systems worldwide become increasingly digital and distributed, utilities are challenged to fulfill their core obligation of providing safe, reliable, and cost-effective service while keeping pace with the new demands being put upon their networks. Of unique importance is the wealth of data now relevant to achieving adequate system awareness. This data comes from disbursed neural centers such as substations, line sensors, and even behind-the-meter sources, and must be collected, organized and interpreted to execute a constantly multiplying array of essential tasks. For the benefit of their entire organizations, utility companies must identify technologies capable of managing the growing wealth of data they are encountering in power systems today and into the future.

The problem: Getting data to all the appropriate people in an organization

Ideally, in this era of energy and digital transformation, every electrical component used in power systems would contain sensors, have some level of intelligence, and possess the ability to communicate information when it is needed to all appropriate people in an enterprise. This scenario would facilitate data-driven organizations with optimized real-time operations and insights into expected events – ranging from weather changes to equipment performance to distributed generation levels and inputs from distributed energy resources – all helping grid operators maximize reliability and resiliency.

The challenge is getting to this desired state. In the real world, legacy systems do not support all the data collected. System operators – but not other potential users – will have access to operations data on supervisory control and data acquisition, energy management, distribution management, distributed energy resource management, substation automation and other systems. Grid managers require the means for securely and timely delivering valuable data from the grid edge and everywhere in between to appropriate staff on corporate networks without burdening operating systems.

This challenge is intensified by the sheer amounts of relevant data, which are growing exponentially. Researchers estimate that the information available on the internet is now measured in exabytes (1018) and zettabytes (1021). Research findings from EPRI and others suggest that that nearly every system upgrade made by utilities toward the grid of the future adds 10 to 20 terabytes (1012) of data volume to their data management requirements. Utilities with processing requirements now well below 200 terabytes will need to routinely manage 800 terabytes and more once they implement such systems as advanced outage management, workforce management, distribution management, advanced meter, GIS, substation automation and condition-based maintenance.

Moreover, data collected by Transmission & Distribution World in a fall 2019 survey indicates that utility respondents consider 14 out of 15 business work areas as medium-to-high-priority for further digitalization, indicating a strong appetite for more data and more capabilities around that data.

The PI System™ is a universal infrastructure for sensor-based data developed to equip users of rapidly growing volumes of data with a solution to the real-world challenges they are now facing.

The PI System can collect, manage, and analyze information from multiple isolated sources across an enterprise and present that data in a way that allows management, engineering, operations and maintenance staff to share important information and solve problems faster. For example, data documenting the performance of a hyperactive load tap changer during the previous 24 hours can quickly be retrieved for review. In addition, PI System alerts can be activated based on preconfigured criteria to provide real-time alerts regarding out-of-tolerance conditions. Following are several case examples that illustrate the use of the PI System to resolve issues that are becoming increasingly common for utilities.

Solution case examples

Managing a wealth of existing and new data with the PI System

A growing municipal utility located in the southeastern United States faced unfulfilled data and business needs across its system involving different control systems such as SCADA, distributed control (DCS) and programmable logic controller (PLC) systems. While optimal systems visibility could require thousands of new sensors, the utility recognized such an expansion of data inputs would totally overwhelm current control systems. Instead, the utility opted to conduct a pilot demonstration with a new system capable of assimilating the expanded data inputs and delivering their information to the company's existing data management system.

The new system provided by Dionomic FogLamp consists of a separate, common data framework that avoids adding new data to mission critical operating systems or proprietary systems with limited potential for expansion. FogLamp is a Linux-based, microservice architecture that is open source. This allowed the utility to build a common platform to be used everywhere for collecting, filtering, and processing events in conjunction with its enterprise PI System.

FogLamp also facilitates the incorporation of built-in plugins for PI Server and OSIsoft (now part of Aveva) Cloud Services using PI Relay. The team successfully used FogLamp plugins to collect data from connected edge (field) sensor devices using available ethernet protocols including Modbus, DNP3 (distributed network protocol) and IEC 61850. The data was then delivered using Docker files to the utility's enterprise service bus and its PI and Asset Framework (AF) servers. The utility also documented use of a PI Server plugin to send data to PI Relay, which automatically configures PI tags and populates AF.

The pilot project demonstrated that Dianomic FogLamp can be utilized like a PI Interface to collect and temporarily store data from many sensors for delivery to the PI System foundation database. The PI AF database model utilizes an easy-to-navigate hierarchal format to organize historical, real-time and future data. The result is significantly reduced time spent accessing, configuring and maintaining data with more time available to utilize high-fidelity, contextualized data to advance business intelligence.

Condition-based maintenance (CBM) with the PI System

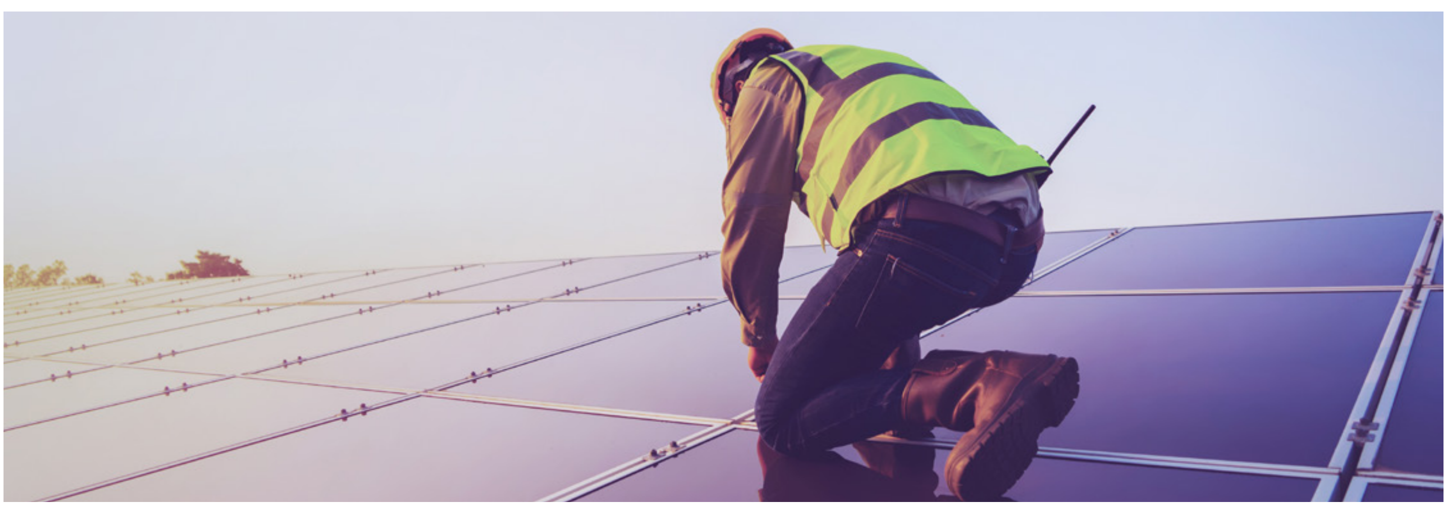
A North American distribution utility uses remote sensing and SCADA to optimize the distribution system in its service territory. The company uses the PI System currently to address the growth of sensors on its system and the expansion of data that entails. However, as growing system complexity continues to challenge old business ways, the utility is pursuing a new means of improving service and controlling costs by shifting from time-based maintenance to condition-based maintenance (CBM).

The utility's CBM program has replaced all scheduled maintenance by leveraging its computerized maintenance management system (CMMS) and the PI System. All work is based on condition or failure identification, which comes from real-time PI Notifications, alerts from the CMMS system and the PI System reports and dashboards. The program provides a high level of situational awareness and a single data repository for information regarding asset health. Time-based data and event frames, which contextualize the data with related parameters, provide company personnel with a comprehensive data environment that can be used to conduct detailed analyses of current conditions as well as root cause analysis, in the event of a failure.

The collection, integration, visualization, and analysis of data is key to CBM. **A major power transformer may have 100 or more sensors that collect data on the following: electrical output; ambient temperature; oil level, temperature and pressure; real-time dissolved gas analysis; tap changer information; cooling fan and pump information; bushing monitoring data; and even geomagnetic disturbance-related conditions.** The sensor data is integrated with CMMS, SCADA and outage management system data using

PI Integrators and a PI Asset Framework model. Templates developed for AF are used to create performance equations, manipulate data sets and conduct asset analytics. Data streams and data analytical results can then be reviewed by appropriate audiences on tablets in the field, on public monitors, in system reports, on user-friendly dashboards developed using PI Vision, or they may appear as real-time alerts to trigger an investigation. In addition, feedback to the utility's CMMS system initiates an automatic maintenance work order for corrective action based upon PI Notifications. The collective process allows staff to focus on prediction and prevention rather than solely reacting to incidents after the fact.

As a result of implementing its CBM program, the utility has experienced improved system reliability, increased equipment availability, improved response time to equipment abnormalities and cost savings, which included the avoidance of potential multi-million-dollar catastrophic failures.



Modernizing substation architecture with the PI System

A gas and electric distribution system operator with more than 4 million customers in a Northern European country began to adopt the IEC 61850 standard – an international communication protocol for substation automation. At least 60 substations in the country are compliant, with an estimated 15 to 20 added each year.

In 2017, OSIsoft (now part of Aveva) built a custom PI Connector to link the company's existing PI System to its IEC 61850-compliant substations. The PI System revealed that tap changers were switching 30 times per day rather than the optimal 16, and allowed the team to attribute peaks in energy usage to trains accelerating at a nearby station. The utility can now predict when assets aren't optimizing performance, take preventative action and reduce outages.

The IEC 61850 system, implemented across the substation network, is built around intelligent electronic device (IED) controllers that are collecting substation asset performance data and recording events. With this information, the company can build smaller, more efficient substations and simplify the process for adding new devices and data sources. This allows the team to perform remote inspections and diagnostics as well as predictive maintenance.

To gain real-time insights from those substations and achieve performance goals, the company had to connect its substations directly to the PI System, allowing it to access substation asset information and real-time measurements, and using Asset Framework and PI Vision to visualize data trends and understand asset performance.

The company plans to hook up more sensors for greater substation information, as well as using the data to perform remote inspections, allowing them to achieve risk-based maintenance goals.

Cyber Security

Cyber-attacks, which are increasingly targeted at electric utilities, range from nuisance incidents to intrusions that threaten safety, reliability and integrity of capital assets.

The PI System offers a defensive posture to address common causes of system failures and misbehavior. First, it inherently reduces risk by limiting direct access to critical systems. Second, the PI System Connectors used to route data from secure areas to PI Servers and users provide additional security boundaries with enhanced protection protocols. Experts also recommend using the safest available architectures for edge devices; always separating control from monitoring systems; having well-guarded remote access; and separating IOT data collection networks. PI Connectors, PI System tools and OSIsoft Cloud Services can help utilities address these and other cyber security issues while ensuring that users get the greatest value from their data.

Conclusion

Intelligent asset networks and data are fundamentally changing the way we produce and use energy. In this new reality, data management translates directly to value creation and retention. Whether addressing a flood of new data sources required for broad system visibility, detailed asset health awareness or actionable information regarding third-party resources on the grid, the PI System offers utilities the technology needed for their digital transformation journey with intelligent, dynamic and real-time data management solutions. More than 1,000 proactive conventional and renewable generation and T&D companies, as well as every independent grid operator in North America are already using the PI System to manage their business data.

Case references

Managing Data Using Dianomic's FogLAMP and PI

A Southeast municipal utility conducted a pilot demonstration using Dianomic FogLAMP to address data management requirements from diverse business units across multiple different proprietary control systems. FogLamp provided a common framework for collecting data and delivering it to the organization's PI System and analytics layer. The benefits of this framework and a case example involving equipment monitoring using B100 IIoT devices to deliver data through FogLAMP to a PI System.

On the Path to Intelligent Maintenance with the PI System

A detailed portrait is provided of a North American distribution company's marriage of its computerized maintenance management system (CMMS) and the PI System to create a powerful condition-based maintenance (CBM) program. A highly illustrated overview also is provided regarding the many PI System tools and applications the organization is using to manage sensor data across its system.

The PI System transforms substation architecture

A Northern European gas and electric distribution operator used the PI System to modernize its substation architecture. Implemented across the substation network, operations rely on intelligent electronic device (IED) controllers that collect information, allowing the company to perform remote inspections and diagnostics, as well as predictive or preventative maintenance that will reduce outages.

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