SOLUTION

Duke Energy began to look at the use of elements of the Industrial Internet of Things (IIoT) and big data analytics to help it meet some of these challenges. For this project, Duke Energy worked with National Instruments, as well as the Electric Power Research Institute (EPRI), OSIsoft, and InStep (now part of Schneider Electric) on custom monitoring and diagnostic infrastructure called Smart Monitoring and Diagnostics or "Smart M&D" for implementation across its fleet and plants.

EPRI has introduced the I4GEN (Developing Insights through the Integration of Information for Intelligent Generation) framework to support power generation companies in their transition to using IoT-related technologies and solutions. This institute supports its partners by sharing expertise and supporting collaboration between multiple power generation organisations, rather than having each go it alone.

Technology investment and operation

Necessary investments for this project included installation of additional online sensors, infrastructure, architecture, and diagnostics applications.

In 2012, Duke Energy began building a new architecture to support this project. Duke Energy made use of the National Instruments CompactRIO platform, which combines an embedded real-time processor, a high-performance field-programmable gate array (FPGA), and hot-swappable I/O modules for real-time data acquisition to a networked host computer. The sensor data is fed into NI CompactRIO monitoring systems, which perform signal collection and processing that can be transmitted by wire or wirelessly to its plant servers. Using the large amount of analog data, NI CompactRIO conducts alarming and provides full waveform analysis for Duke's data specialists. Additionally, Duke Energy was able to use NI InsightCM™ for condition monitoring to visualize and analyze data. By connecting an FPGA and an on-board real-time processor to the sensor, raw analog waveforms can be reduced to conditions indicating the "health" of the system at the node itself. This prevents the data overload condition in which subject matter experts are stuck looking for problems that are difficult to locate.

NI InsightCM software was an important tool in making the data more user friendly, and more broadly accessible beyond the small technical team. This is an on-going process, where Duke is supporting the transition from traditional to new technology to support their end users.

Additional sensors were added to equipment with more limited monitoring capabilities such as drives, motors, pumps, gearboxes and fans. For machines already equipped with sensors, Duke Energy focused on expanding sensing capability. For example, steam turbine generators already had a high level of sensing as these expensive machines need alarming to avoid costly failures. Duke Energy added more sensors to this type of equipment to capture data to support more advanced vibration monitoring, which enhanced the predictability of future failures.

Duke Energy identified over 10,000 assets across their facilities and made plans to add more than 30,000 sensors to its equipment assets, including accelerometers, temperature sensors, oil analysis sensors, thermal cameras and proximity probes. These sensors added functions such as monitoring vibration, bearing temperature and oil pressure, as well monitoring other assets such as transformers, dissolved gases, and electromagnetic signatures on generators.

An estimated 75% of the cost of this project was not in the software or sensors, but related to the cost of wiring the sensors to the data acquisition computers. Data acquisition systems are spread throughout Duke Energy facilities and can connect up to 30 or 40 hardwired sensors. Cabling must be run from the sensor to the local data acquisition computer; then signals are wirelessly transmitted from NI data acquisition devices to Duke Energy's servers.

To collect vibration information, it can be necessary to capture anywhere from 10,000 to 100,000 samples per second for several seconds to obtain a good measure of the machine condition. To help manage this large amount of data, Duke Energy uses a combination of on-site plant servers. Every plant has its own OSIsoft PI servers, which collect, store and organize the data from a range of sources.

These servers are located in Duke's Monitoring and Diagnostic Centers, where Instep's Prism pattern recognition and prognostics software (used for mechanical solutions) and GP Strategy's EtaPRO thermal condition monitoring software are used to identify deviations from expected behaviour. Within the monitoring diagnostic center, there is a team of five technical people using these software tools.

The technical staff sees a dashboard of alarms that will tell them if the equipment has had some unexpected behaviour. At that point, they can investigate and screen the issue to decide if it is a true anomaly and needs further investigation. If it is flagged, there is a standard process email sent to alert the correct people on the issue; and give them information in graphical form pinpointing deviations and advising on an initial diagnosis, so the operator can go check the machine.

This information can be sent to EPRI's asset health management system, to identify the issue through comparison against all known faults in a signature database compiled over time (from multiple companies) using data from real equipment. EPRI can then notify Duke Energy specialists to go into the NI InsightCM Data Explorer (web-based software designed to help engineers quickly locate, inspect, analyze, and report on measurement data) and do the full analysis.

Currently, Duke Energy stores all of its data on internal servers, as the IT department is not currently open to the use of the cloud. To date, Duke Energy has been able to cope with the volumes of data collected using this method.

OUTCOMES FOR DUKE ENERGY

As of March 2017, nearly 2000 CompactRIO systems have been deployed and managed by the Smart M&D architecture across 30 facilities. Within these plants, Duke Energy relies on automated data collection, allowing analysts to spend 80% of their time on analysis, rather than data collection; thus, the analysis is more robust.

Over a year, Duke Energy averages two notifications per day at its Monitoring and Diagnostic Center, using Prism; only one in four of them requires corrective action. These alarms give specialists a window to plan and fix the equipment at the time when the cost will be lowest, for example when the plant is due to be down for maintenance, or at times of lesser demand.

The machines may be able to continue functioning for several weeks, allowing specialists to choose the least costly time to schedule repairs. In one instance, Duke Energy was able to keep a generator operational for three weeks, despite a faulty bearing, by nursing it along until it could schedule a safe and convenient repair.

The company has moved from collecting four readings from a data point per year to collecting readings every five seconds. Not all of the additional data can be stored forever; so data management protocols are in place to decide when and what types of data are discarded, to support a more intelligent storage plan.

Over four years, Duke Energy has avoided costs of 130% of the capital budget spent due to avoiding the higher costs associated with failures. The third year of the project was when Duke Energy began to see a significant pick-up in payback.

The company is also in the process of calculating labor cost savings through avoiding manual collection of data. Since the systems are analyzing data constantly, operator rounds can be greatly reduced while the frequency of data collection can be dramatically increased. Data no longer need to be collected every month; it can be collected several times per day resulting in many terabytes of data per week, allowing issues to be discovered and tracked on a more frequent, consistent basis.

This shift has improved reliability and lowered operating costs to meet the challenge from executives to increase reliability and optimize the activities of the workforce by being more analytical.

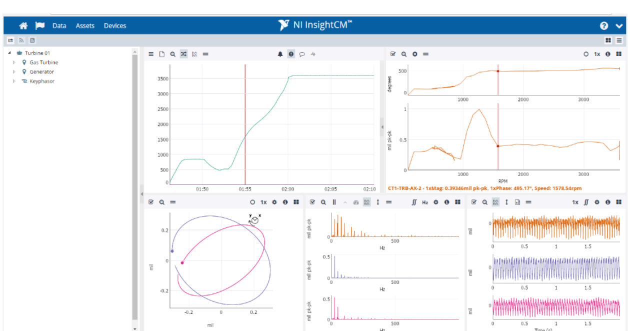

Figure 2: Web-based software for condition monitoring (NI InsightCM pictured)

CHALLENGES

Many challenges had to be overcome in rolling out this solution.

Early in this process, Duke Energy realized it would not be able to complete this project easily on its own. It avoided many challenges by partnering with technology provides such as NI and EPRI from the outset.

1) One challenge Duke Energy did face was getting its employees, many of whom have spent their entire careers practicing route-based data collection, to change to these new methods and to trust the technology and its information. For example, it is still very common for specialists to receive a warning based on the data and follow up by manually checking the equipment with handheld devices. Consequently, the company has invested and continues to improve on the visualization of the data.

"You need to make it so simple that they want it and seek it out because it's so simple to understand and read."

Michael Reid – General Manager of Technical Programs – Duke Energy

2) Another major challenge faced was the large number of advanced pattern recognition (APR) models running (over 10,000), resulting in high volumes of alarms received. To cope with this, Duke Energy is setting a strategy to manage and prioritize alarms, as it doesn't have enough analysts to cope with all the models. One method it is using to manage this is asset prioritization based on the criticality of the asset (for example of. steam turbine versus a. fan).

3) For each of the four regions where this solution is running, Duke Energy has established leaders, who work with the maintenance specialists taking the measurements, helping them to take the new technology into the business. However, no-one person has all the skills; so from the start it was important to for the OT and IT teams to work together.

   This introduced a challenge in that the OT and IT departments had their own, and sometimes competing, priorities (and budgets), so it was critical to maintain a balance; senior executive sponsorship of the project was important, to ensure sufficient and continuing funding.

4) As the project has been rolled out across multiple facilities, the team has had to work with each station to develop unique solutions for its specific needs. This required the buy-in of the plant managers, based on their key pain points and concerns. Another challenge is that, over the last few years, plant managers have changed and so on-going training of new staff is required.

NEXT STEPS

This year, Duke Energy will complete deployment of additional sensors; as it recently expanded the scope of what it would like to monitor to include additional equipment such as transformers. In the future, Duke Energy recognizes that there is a great opportunity to save additional money by using more wireless sensors, which do not require costly cabling to the data acquisition systems.

Further down the road, Duke Energy hopes to move toward gaining more actionable intelligence with tools that can diagnose problems upfront. It would like to move from the predictive maintenance solutions currently employed, to ones that tell an expert not only what the problem is, but also provides recommendations on how to resolve it. This will become especially important given the attrition of subject matter experts in this industry.

Fig. 3 Duke Energy facility

[**Read the White Paper: Addressing Challenges of Online Monitoring**]

For more information

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