Predictive Maintenance in Water and Wastewater Facilities

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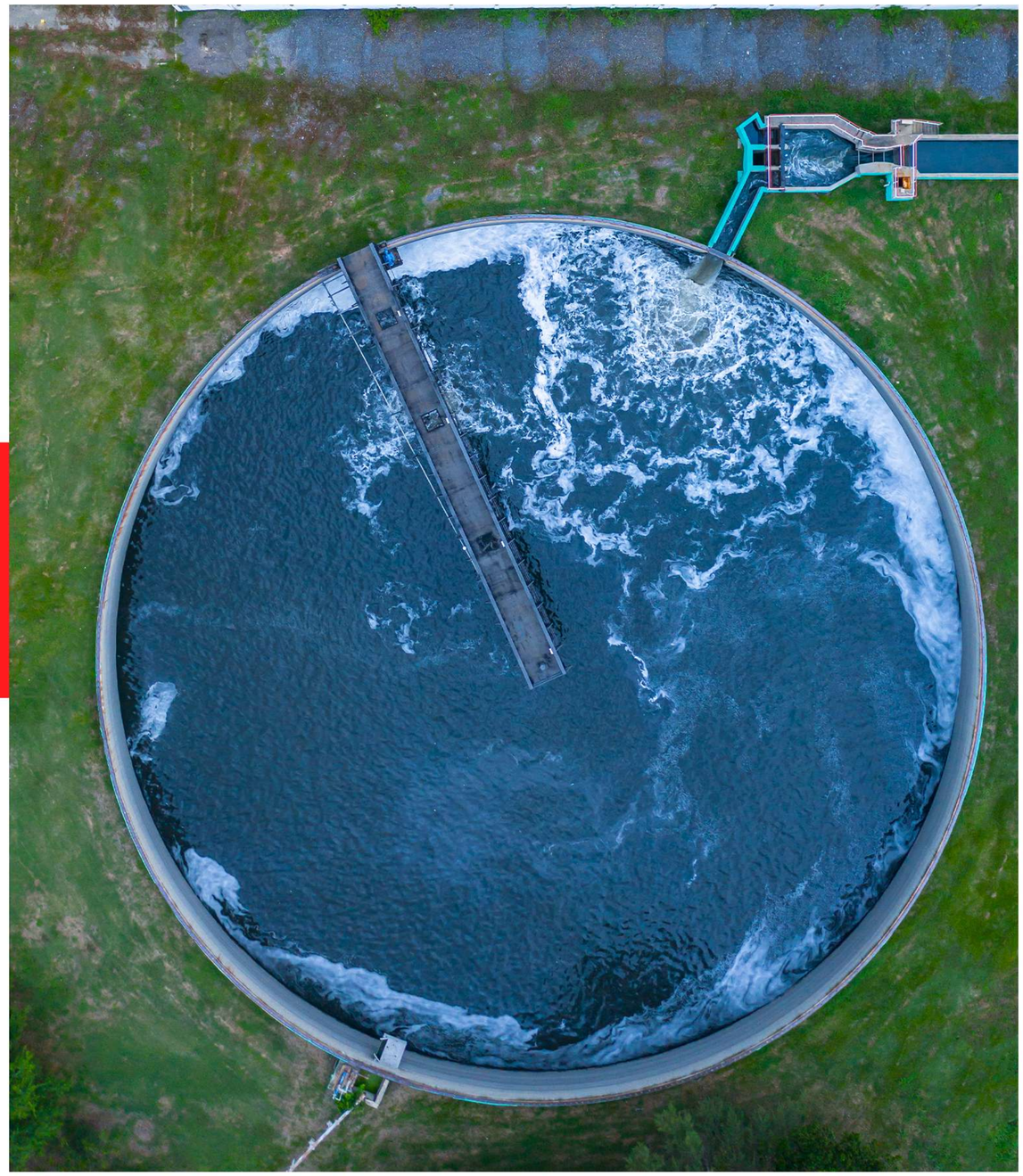

Figure 1: In the United States, 231 cubic meters of wastewater are recycled annually per capita. In addition to increasing this number, improving the quality of water is of great importance for a more environmentally friendly

Predictive Maintenance in Water and Wastewater Facilities

Rapid urbanization in the last 50 years and its effects are felt intensely. Undoubtedly, one of the most important processes of urbanization is water and wastewater management. Moreover, the global climate crisis and water scarcity show that these facilities will become increasingly important not only for urbanization but also in all areas of our lives. Failures or unexpected stops in treatment plants not only decrease the quality of the water obtained, but also increase operating costs and damage one of the most important functioning mechanisms of our cities. In this document, we will take a closer look at how predictive maintenance practices can contribute to the production and maintenance efficiency of water and wastewater facilities, while examining the innovative solutions Artesis offers for these facilities.

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Key Challenges in the Waste Water Industry

Wastewater facilities are an integral part of the infrastructure of our cities. However, the rapidly increasing population, the increase in service demand, the decreasing number of personnel and the difficulties in the budget cause serious pressure on these treatment plants. For example, while approximately 99% of households in Germany today are connected to a treatment plant, there is a basic condition for the system to be consistently successful. It is to be working continuously **24 hours a day, 7 days a week**. To achieve this, perfection is required in almost every field. Today, we can list the obstacles in front of the digitalization of treatment plants and their acquisition of a smarter process as follows.

- Since the wastewater facilities were commissioned almost at the same time as the establishment of the cities, these facilities have an old and non-modern infrastructure.
- Bureaucracy and budget is an important problem as it is usually established with public partnerships.
- The number of manpower compared to the workforce in the facility is less than expected.
- For security reasons, it is not very willing to intervene in the facility from outside.
- Asset management awareness has not become widespread.

Fact

U.S. public treatment plants treat more than 8 million tons of dry weight sludge per year. One-third of the electricity produced in the USA is consumed in these treatment processes.

Figure 2: According to the US Environmental Protection Agency, 63 million Americans have been exposed to contaminated water at least once in the last 10 years.

The Importance of Predictive Maintenance for **Water and Wastewater Facilities**

Considering the above challenges, you might think that predictive maintenance can find solutions to the main problems that wastewater plants may experience. However, before digitalization and the Internet of Things, many traditional predictive maintenance methods faced many difficulties in implementation in these huge and demanding facilities. Digitalization, IoT and artificial intelligence are now very successful in overcoming these problems. With the sensorless and online status monitoring methods we have developed as Artesis, we prevent unplanned downtimes that may occur in these facilities and significantly increase the quality of asset management.

Let's take a look at the important benefits of predictive maintenance practices in wastewater plants.

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Preventing unexpected problems: Each piece of equipment is of great importance for an uninterrupted process in water treatment plants. Not only large feed pumps, but even a problem with a chemical injection pump can cause certain lines to fail. Predictive maintenance helps you take timely measures by predicting these possible malfunctions.

Reducing maintenance costs: Planning maintenance and preventing unnecessary maintenance in waste water plants, which are huge facilities, saves time and money. Predictive maintenance helps to digitize your maintenance processes by preventing unnecessary maintenance processes.

Increase in energy efficiency: The energy consumed per clean water obtained is an important KPI value for wastewater facilities. Monitoring pumps and motors with predictive maintenance and intervening before they fail not only prevents these equipment from working inefficiently, but also contributes significantly to energy efficiency by eliminating unplanned downtime.

Improvement in asset management: Effective maintenance management gives you more benefits than just improved ROA (Return on Asset). Fewer downtime and demonstrably good holdings emphasize your credibility with your customers, investors and other stakeholders. Clear management and easily accessible essential information are important for your maintenance personnel, helping them save time in their day-to-day work and focus on the most relevant asset maintenance issues. Additionally, using the latest technology strengthens your reputation as an industry pioneer. The fact that it is generally realized with public partnerships in waste water facilities makes reputation management important.

Fact

It doesn't matter how well a process is designed, how ingeniously constructed, or how expensive the components are; If maintenance fails, the entire system fails.

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A Revolution in Condition Monitoring

e-MCM Sensorless Condition Monitoring Solutions

Reasons such as the wide-spread structure of water treatment plants, the excessive number of equipment in hazardous and hard-to-reach areas, intensive labor and very intense data flow require a special condition monitoring solution. The e-MCM sensorless condition monitoring solution we offer as Artesis responds to all these challenging needs of wastewater plants.

How e-MCM Works?

Fact

e-MCM's patented machine learning algorithm offers comprehensive fault detection up to 6 months in advance. Thus, malfunctions in pumps and motors are caught at the initial stage.

The e-MCM continuously monitors your rotating equipment, takes measurements and compares them with the digital twin it creates during the self-learning process. The unique machine learning algorithm allows it to recognize normal operation in a wide variety of conditions such as different speeds or loads, providing control without false alarms.

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Easy Installation

Easily Monitor All Your Pump, Motor, Fan and Centrifuge Systems

The need to install in narrow areas where we often live in water treatment plants and the problem of accessing dangerous areas ends with Artesis. The e-MCM only needs three-phase voltage and current connection via conventional current transformers (CT) and voltage transformers (VT). Usually the e-MCM is installed in the engine control cabinet. This eliminates the need to install equipment in hazardous and challenging areas.

Figure 3: Artesis's sensorless condition monitoring solutions offer an effective solution even in the hardest to reach areas.

Which Faults Can Be **Detected In Advance?**

Artesis e-MCM offers comprehensive solutions in the detection of both electrical and mechanical faults.

Electrical and Mechanical Failures

- Loose foundation / components
- Mechanical imbalance / misalignment
- Transmission faults
- Driven equipment malfunctions
- Gear box, belt, coupling and bearing failures
- Stator and rotor faults
- Internal electrical faults
- External electrical faults

Process Failures

- High energy consumption
- Low efficiency
- Cavitation in pumps
- Flow turbulence in fans, blowers
- Contamination in the filter and heat exchanger
- Lubrication
- Overload

Fact

As we mentioned before, the energy consumed per extracted water is an important KIP value for water and wastewater facilities. Artesis e-MCM provides you with very important and critical data by showing the effect of malfunctions in your facility on energy efficiency.

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Easy and Digital Use

Many predictive maintenance methods are difficult to operate even after they are installed. Artesis e-MCM provides a fast and easy use with its automatic fault diagnosis feature. Instead of dealing with dense and complex data, maintenance personnel take quick action only with actionable data.

After installing e-MCM systems in your treatment plant, Artesis IoT platform communicates easily with e-MCMs. You can establish a wireless connection by integrating a 4G / LTE router into your system that allows communication between e-MCMs Artesis IoT cloud platform. Integration packages are available for a wide variety of third-party systems, including integrated condition monitoring, SCADA/HMI, and reporting/business intelligence.

Real-Time and Error-Free Monitoring

The e-MCM continuously takes measurements and compares them with the baseline condition to assess the severity and type of any developing faults. It can recognize anomalies in a wide variety of work situations and even expand the self-learning process further when it recognizes that it has gone beyond the original learning boundaries. This allows the e-MCM to detect faults very precisely without false alarms. These real-time data provided by Artesis are an effective method for solving problems such as cavitation and impermeability, which are seen in pump systems and progress quite quietly.

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Integrated Solution Needed by Water Treatment Plants

Artesis e-MCM also allows users to perform Power Spectral Density Analysis and detailed trend analysis without the need for additional sensors. It can also act as an intelligent component of a complete monitoring and diagnostic system throughout the water treatment plant. By integrating with OPC, you can connect the e-MCM to your own systems and have the results presented to your maintenance personnel via existing imaging systems. In addition, by integrating this advanced diagnostic and maintenance data provided by Artesis to your own remote monitoring system, you can establish a 360-degree smart monitoring system throughout the facility.

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We Don't Come From The Future!
We just use data wisely!

In addition to all these features of Artesis e-MCM, its superior reliability level manual controls significantly reduces the need for redundancy and your preventive maintenance needs. Artesis's unique technology will tell you when machines need maintenance with very high accuracy, minimizing your unnecessary inspection and maintenance planning processes. Knowing when a failure will occur months in advance will play a critical role in improving the asset performance that water treatment plants need.

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Why Should Water Treatment Plants Choose Artesis Technology in 5 Steps?

1. Quick and easy installation in hard-to-reach and dangerous areas

2. Unique know-how, thanks to the equipment installed in water treatment plants all over the world to date, comprehensive diagnosis of malfunctions 3-6 months in advance

3. No calibration required and no subscription software fees

4. Minimizing the time loss of maintenance personnel with a digital and online monitoring and diagnosis system in water treatment plants spread over a wide area.

5. Easy diagnosis of troublesome and hard-to-find faults with real-time data transfer

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Case Study

Sustainable Predictive Maintenance at PUB for Improved Reliability of Water Supply System

Through online monitoring and transmission of sensor data, intelligent machines enable PdM and move closer to the goal of “no unplanned downtime”. The ability to proactively manage assets allows condition monitoring to have a direct impact on operating efficiency. Getting the most out of assets involves parallel improvements in both efficiency and availability. According to the US Department of Energy [6] “Well-executed operations and maintenance (O&M) programs promote energy efficiency and lifecycle performance, which can save Federal agencies 5% to 20% on annual energy bills without significant capital investments”. Although benefits of PdM are widely accepted, enterprises taking full advantage of the approach to achieve sustainable PdM remain relatively small. For many users, the complexity of traditional condition monitoring systems remains a significant obstacle. The approach presented here provides a simple, inexpensive and easy-to-install solution which makes it possible to implement a sustainable PdM program. It also avoids putting a heavy setup and analysis burden on busy maintenance staff. The solution can also be integrated with IIoT platforms providing fault labels to their machine learning algorithms. This accelerates the learning process of the platform as well as supporting enterprises to selecting more efficient sensors and features.

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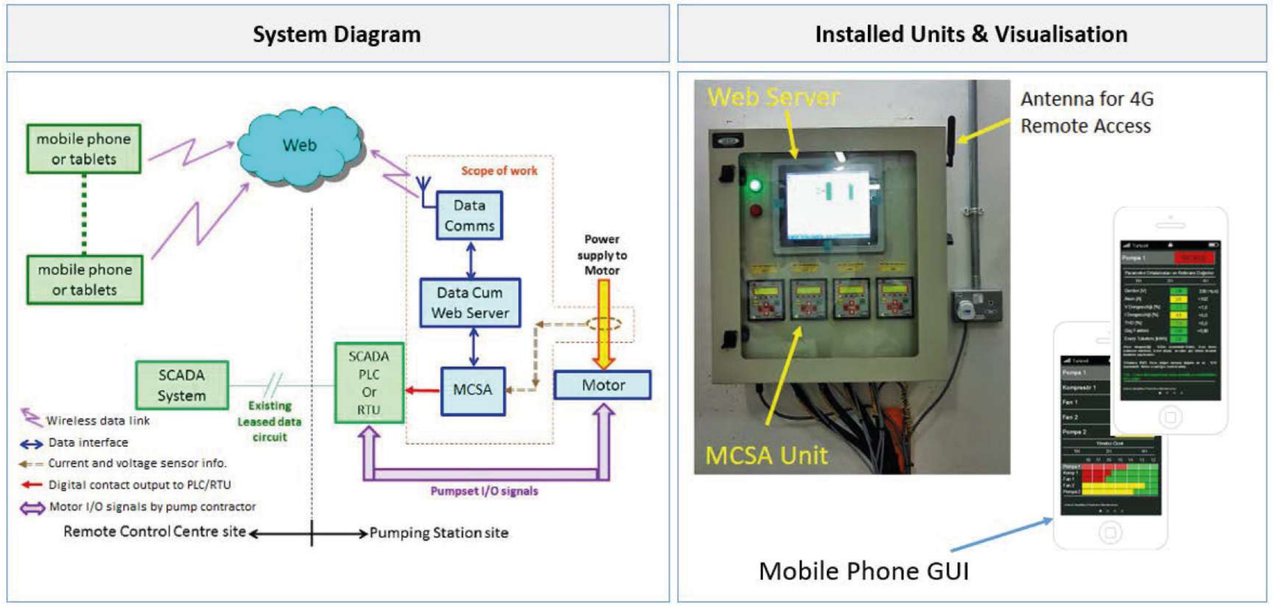
METHODS

This section elaborates on the use of a Motor Current Signature Analysis (MCSA) methodology [3] for real time condition monitoring of Pumpsets and how it was designed to co-exist with the end point protection of Pumpsets to achieve Protection-in-Depth. The first outer layer serves as the end point protection of Pumpsets. This is implemented solely via a “Hardwire System” with discrete sensors, relays but without any firmware/software dependent components in the loop. The second layer (i.e. the MCSA) provides the inner protection layer and it give the maintenance personnel early alert and warning on the root cause and impending failure. It allows timely intervention of mitigating measure by the maintenance personnel to avoid the “Run-To-Fail” situation. The MCSA system also provides trigger to issue work orders in any Asset Management System (AMS) as well as energy efficiency information. As seen in Figure 1, the MCSA early warning system communicates with Web Server and its results are accessible from anywhere through OPC server (SCADA, ERP, PC, tablet, mobile phone etc.) by maintenance people to take proactive action. Warnings are also given by e-mail notification. The SCADA system is isolated from the Web Server for cyber security purposes. The MCSA relay output is interfaced to the SCADA system via opto-isolated Digital Input card for the SCADA to capture as a record in the event of a detected abnormality. The operator is not expected to take action on this information, rather he is expected to communicate with maintenance department to schedule maintenance. The MCSA system also generates a Short Message Services (SMS) alert to selected Operation and Maintenance personnel via a separate 4G cellular service on detection of abnormality. This split path alert reporting procedure ensures that no one will miss any alert generated from the MCSA system.

Figure 1 System diagram of the early warning mechanism (left) and the installed units at Marina Raw Water Pimping Station (MRWPS) site The online MCSA approach deploys advance system identification algorithms for real time condition monitoring and fault detection which were originally developed under several NASA contracts [1, 2, 4, 5]. It uses measurements of voltage and current waveforms (sampled at 2.5 kHz) only and automatically initiates a self-learning phase during which it builds up a reference mathematical model [3]. This model based approach is included in the ISO 20958:2013, which provides information about the electro-mechanical characteristics of the motor and its driven equipment (e.g. pump, compressor, fan etc.). The system is able to learn all operational profiles during its training period, such as different speeds and loads. Mechanical (e.g. unbalance, bearing), electrical (e.g. stator) and process related faults (e.g. plugged filters, leakage) are indicated with equipment and corrective actions are suggested.



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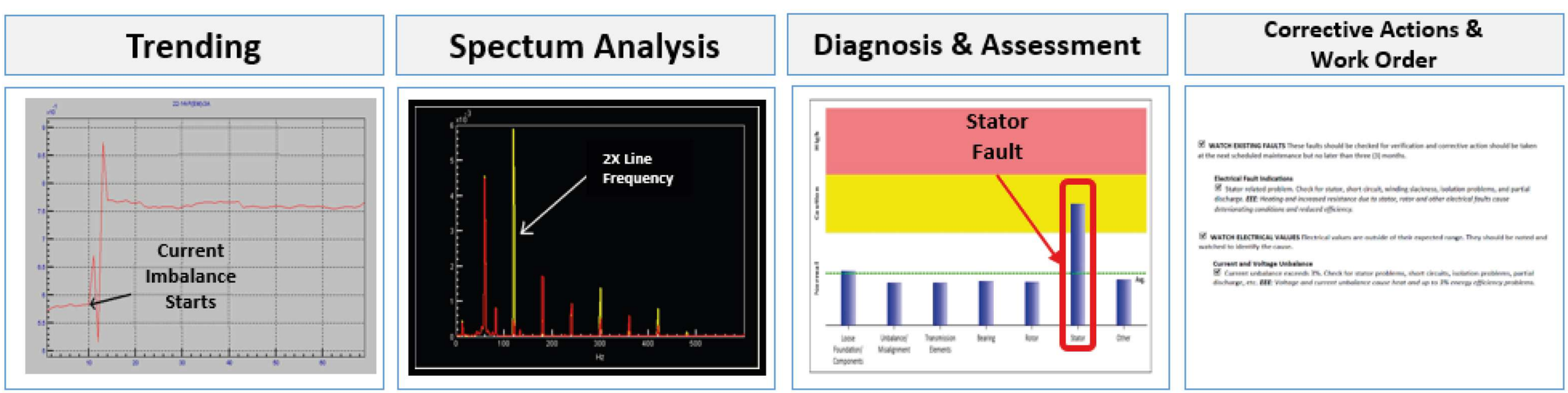

Figure 2 Stator fault diagnosis and work order suggestion of a submersible pump MCSA system gives the diagnostic information in a user-friendly format such as bar graphs. Figure 2 displays the spectrum analysis and fault trending of a stator winding fault of a submersible pump. The spectrum graph is further simplified and converted into a bar graph so that a foreman, a technician or an engineer can use it effortlessly. Corrective actions and work order suggestions indicating what is wrong, what should be done, and how soon it should be done as well as the effects of these faults on the energy efficiency are also given. Physical parameters of the monitored equipment such as current and voltage unbalance, active and reactive powers, and total harmonic distortion are also continuously calculated and updated in the result displays.

RESULTS AND DISCUSSION

The monitored equipment at PUB sites varies; deep well submersible pumps, sewage treatment vertical suction pumps, drainage pumps, water transfer pumps and many more. After a successful pilot monitoring at Marina Raw Water Pumping Station (MRWPS), the early warning system has been installed at different sites, some of which are: Marine Barrage, Ulu Pandan Water Reclamation Station, Ulu Pandan New Water Pumping Station, Jurong Water Reclamation Plant, Johor River Water Work, Bedok Pumping Station, Lower Seletar I & II Pumping station, Upper & Lower Peirce Pumping Station, Kranji Pumping Station, Pandan II Pumping Station, Tengeh Pumping Station, MacRitchie Pumping Station. The following subsection gives a case study for a deep well submersible pump.

Case Study

One of the MCSA units monitoring a 3.3kV deep well submersible pump at the MRWPS site was giving a warning about the pumps condition. The warning was given due to high level of unbalance in the system which was verified by the existing SCADA system. SCADA display indicates a high vibration triggering on pump at non-driven z-axis as seen in Figure 3. Maintenance crew confirmed that the unbalance problem was due to some big debris, damage the bandscreen, and went through the propellers.

Figure 3 Unbalance fault detection in both SCADA and MCSA screens

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Conclusion

We need water and wastewater facilities more than ever for a sustainable urbanization. Although the old structure of these facilities and bureaucratic barriers delay renewal and digitalization, the rapidly spreading IoT and predictive maintenance applications offer new opportunities like never before. The innovative predictive maintenance solution we offer as Artesis can make it easier for you to switch to your smart maintenance and asset management system that you have postponed until now. We look forward to sharing with you the know-how we have gained thanks to the situation monitoring system we have established in many different continents around the world.

“If there is magic on this planet, it is contained in water.”

Loren Eiseley

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Contact Us

If you have any queries related to condition monitoring for water treatment, please kindly contact us.

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