The IWInfra: An Informed Wastewater Infrastructure

IWInfra solution utilizes an Eden cloud to do AI analytics on wastewater processing plants predicting maintenance via secure digital assets

IoE.

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Abstract

Wastewater treatment plants have been adopting the advancements' technology for several years, e.g., Internet of Things (IoT) devices, Artificial Intelligence (AI), and Machine Learning (ML), among others. As they know, the UN has emphasized that wastewater is an "essential component of a circular economy" and called for more wastewater to be treated and recycled globally. A selective approach for multiple wastewater recovery is desirable and technologically feasible to provide water at specific quality standards for each reuse objective.

Although there are many challenges for the wastewater industry, the biggest of them all to reach the goal of sustainable handling of wastewater and sludge is how to keep maintenance costs down. Current digital technology advancements are paving the way for a solution to the maintenance problem. Still, throughout this process, there has been a common issue hindering the implementation of technological devices - data security. A concern that arises from the interconnectivity of devices, sensors, computers, and machines, that don't have a security-first approach.

With the cybersecurity risks in mind and the high investment costs that digitization accounts for, decision-makers in the Water and Wastewater Systems (WWS) try to avoid digital. The IWInfra acts upon the security problem by developing a device-cluster, decentralized software infrastructure, blockchain-secured, and with a knowledge-based AI to keep data, storage, analysis, processing, and delivery at the source. Resulting in service, capable of predicting maintenance by offering data to information refinement on a real-time 24/7 basis.

The IWInfra solution utilizes an Eden cloud to do AI analytics on wastewater processing plants, using vibration and sound sensors to collect data refined into information outcomes on the Eden cloud. The information outcomes focus on predictive asset management but can be used for autonomous automation. The outcomes are accessed through a "mobile-first" Insights Portal App. The App has User features such as digital key access, time-based access, geolocation control, and functional features such as Continuous Information (hourly, daily, weekly, monthly, and yearly from-start). The IWInfra is about stepping out of Preventive Maintenance and into Predictive Maintenance, saving money, and lowering plant disruptions, all within security beyond the cyber environment.

Introduction

The importance of predictive maintenance can be exposed in simple terms, indicating that fixing something before it breaks is more cost-effective. Using this approach to critical infrastructure, i.e., water and wastewater infrastructures' treatment plants, the benefits result in avoiding downtime, which improves productivity. It also extends asset life; repairs become less complex and costly, eludes collateral damage, assures regulatory standards and compliance, and provide better spare parts, materials, and inventory management.

In addition to the transition from preventive or reactive maintenance to predictive maintenance, Informed Wastewater Infrastructure's (IWInfra) security beyond cyber approach safeguards data generation at the source. A solution mitigating centralized data management approaches' risks, e.g., cyberattacks, latency, and bandwidth costs.

Having these advantages rolled out actuate positively on the net income. A picture that makes it easy to understand the importance predictive maintenance technologies and practices add to infrastructure:

- "Across almost every asset-intensive industry - such as oil and gas, manufacturing or transportation - organizations are challenged with how to maximize the value of assets throughout their lifecycle." [1]

The following sections will be describing in detail this innovative infrastructure's maintenance approach:

- Wastewater maintenance: Description of current wastewater management techniques and processes.
- Preventive maintenance: Looking into how wastewater infrastructure is currently maintained and its drawbacks.
- Predictive maintenance: This new approach to water and wastewater infrastructure management is plausible via new technologies.
- Informed Wastewater Infrastructure: Explains the way technology is applied to service water and wastewater treatment plants' infrastructure with predictive maintenance.

Wastewater maintenance - the way wastewater is being handled today

Wastewater maintenance combines inspections and tasks a team does to keep a wastewater treatment plant up and running, delivering clean water to communities while maintaining pollutants out of the environment. Wastewater treatment is turning wastewater into an effluent that can safely return to the water cycle. The treated water can either be released into the environment or reused in reclamation.

There are many types of treatment for wastewater, but they all tend to have the same kinds of assets, including:

- Wells
- Valves
- Pipes
- Pumps

As the wastewater moves through the phases of the process, it travels between large storage tanks. Once in the facility, the wastewater can pass through different types of treatment. Physical water treatment is, for example, a combination of filtering and skimming. Some facilities use sedimentation, while others rely on aeration, but no chemicals are added at this stage.

Then there is biological wastewater treatment, where microorganisms metabolize the organic elements. And another type is chemical treatment, where plants add chlorine or ozone. Finally, there is the sludge treatment, where plants work to get the maximum solids from the liquid.

Key goals & problems

Wastewater maintenance is all the work done to keep the assets and equipment up and running. The goal is to maximize uptime, minimize unscheduled downtime, and use the shortest possible time and money. An additional goal is to extend the life cycles of assets to get the most value out of them before replacement.

Wastewater maintenance is challenging because of the size and complexity of the assets and the severe consequences when things fail. Most obviously, it would be dangerous if wastewater could reach the environment. But it would also be hazardous if the plant were to lose control of many of the chemicals it uses at different stages in the cleaning process, including chlorine and ozone.

On top of the environment, there are regulatory and political issues too. Many of these facilities fall under the authority of the Environmental Protection Agency (EPA), which can aggressively sanction facilities with hefty fines.

When it comes to the technological development of the maintenance procedures, wastewater treatment plants have for several years been adapting to the advancements' technology is servicing, e.g., Internet of Things (IoT) devices, Artificial Intelligence (AI), Machine Learning (ML), among others. There has been a common issue hindering the implementation of technological devices - data security. A problem arising from the interconnectivity of devices, sensors, computers, and machines, that don't have a security-first approach.

Preventive maintenance - general method applied today

Like any other production process, wastewater treatment processes involve different costs, such as energy, personnel, maintenance, and reagents. In the last years, they have become an issue of great concern to many operators regarding maintenance costs. Maintaining the facilities in good condition ensures the proper performance of these infrastructures and reduces the risk of failures. It should be known that equipment breakdowns imply an increase in operating costs, with a high risk of generating environmental damage due to the malfunction or the stoppage of the process. Preventive maintenance policies are portrayed as the best strategies to reduce equipment breakdowns and repairs, to address this situation.

Drawbacks of preventive maintenance

The big drawback with preventive maintenance is that while preventing failures, the wastewater facility will do a lot of unnecessary maintenance work just to be on the safe side; this is not cost-effective in the long run nor sustainable.

Predictive maintenance - a new, more sustainable approach

Predictive maintenance is a technique that employs data-driven analysis to detect anomalous working conditions and predict future failure risks of assets. Despite wide applications in the manufacturing and oil and gas industries, the application of predictive maintenance in infrastructure facilities, such as wastewater treatment plants, is scarce. The recent advent of information and communication technologies and artificial intelligence presents an excellent opportunity to enhance the practice of infrastructure maintenance by integrating predictive maintenance techniques.

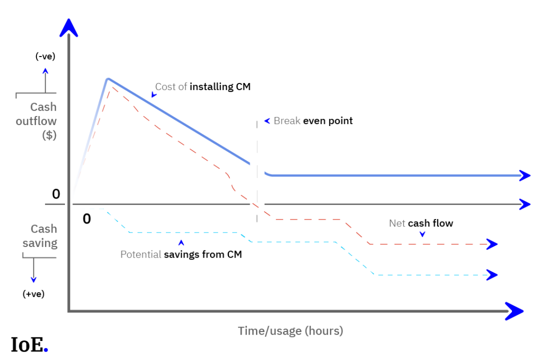

Figure 1 - *Typical overall cash flow from an investment in predictive maintenance.* [2]

Capabilities of Predictive Maintenance

Competent predictive maintenance merges raw data from IoT and instrumentation with AI-measured analytics through digital networks.

Integration is crucial for organizations using these systems

Organizations must monitor an array of technological and physical IoT assets. To achieve it, they need to accurately track, gauge, and manage assets while running applications through data silos ("private garden"). Integrating "private garden" systems improve efficiency by determining potential system failures and relaying information to the organizations' decision-makers to act, based on the analysis of the data, before a problem occurs.

Internet of Things (IoT)

Real-world IoT data such as population changes, traffic patterns, weather measurements, and real-time energy consumption can improve the accuracy of predictive maintenance. In wastewater treatment, an increase in the local population directly affects the stress on all connected facility water systems. It can affect water levels for farming or industrial production, for example. IoT can analyze the total picture of millions of interconnected pieces of physical equipment to remotely analyze and optimize the management of those devices throughout the entire network.

Data Quality Analysis

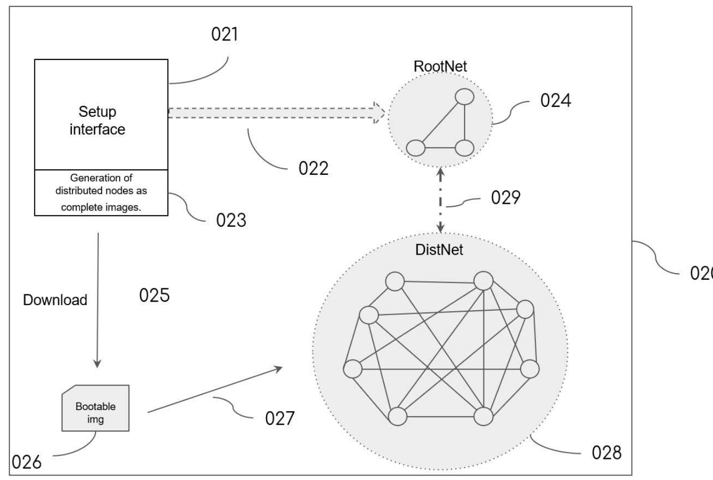

Figure 2 - The *IoE Informed Wastewater Infrastructure customer signup chart process.*

A crucial component of predictive maintenance is the accuracy of data produced. If the health of asset data is compromised or inaccurate, analysis cannot be trusted and is not possible. Machine learning, AI, and predictive analytics can be directed towards large amounts of operational data information. But only with verifiable data, analyzing data accuracy crucial to producing reliable analysis and predictive maintenance recommendations.

Reliability & Sustainability

Using the advantages of predictive analysis, engineers can develop models for equipment life expectancy based on verified data within a system, allowing organizations to focus on high-risk areas that most adversely affect system reliability and need the greatest maintenance.

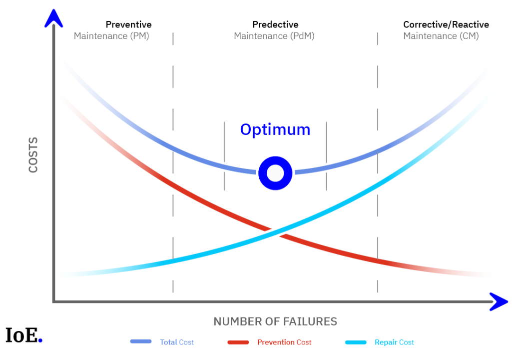

Figure 3 - *Relationship between maintenance costs and numbers of failures under different maintenance methodologies*.

Maintenance strategies can therefore be developed to enhance reliability and efficiency. For example, the analysis may indicate fatigue in current equipment and prescribe maintenance to minimize and avoid equipment failure. Or, the analysis may suggest that the current system maintenance practices and schedules prevent component fatigue or failure and prescribe no changes. Knowing where and when to perform maintenance helps to eliminate time-wasting costly redundancies.

Informed Wastewater Infrastructure (IWInfra)

To reach predictive maintenance, we have developed IWInfra.

What is IWInfra?

IWInfra comprises a decentralized software blockchain-secured layer. This provides wastewater treatment plants a secure means of communication between the sensors installed in the devices being used (pumps, dryers, motors). In addition, a hardware layer facilitates the clustering of the nodes to process the data obtained, resulting in an efficient and secure predictive maintenance for any step of the process.

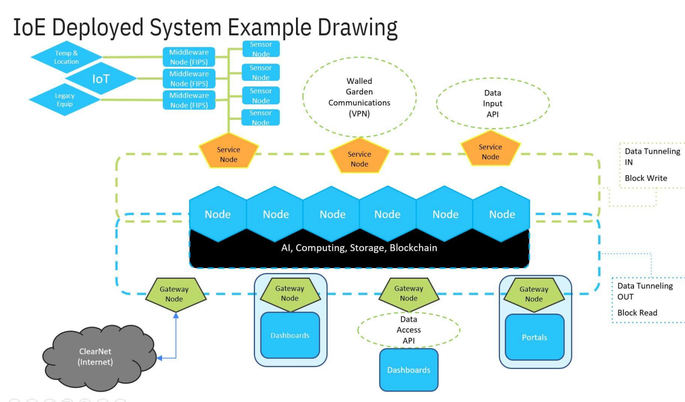

Figure 4 - *How a deployed IoE Informed Wastewater Infrastructure works*.

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IWInfra Benefits

The IWInfra implementation presents a series of advantages to Water and Wastewater treatment plants, consisting of:

- **Predicting asset failures** - The feasibility and accuracy capable of going beyond time-scheduling maintenance and into condition-based action and prediction of future failure probability; rely on machine learning and data analytics. A solution that significantly decreases asset failures and their consequential costs. The IWInfra Analyzation & Prediction Engine looks for patterns in asset data, usage, and the environment. It correlates those patterns with any known issues to help reliability engineers and maintenance managers predict failures and share data and scoring.
- **Igniting condition-based maintenance** - IoT devices deployment generates data via asset sensors coming from weather conditions, asset records, and work history. In such a way, asset management's health improves asset availability and drives efficient replacement planning. The IWInfra dashboard App enables a consolidated, global view. With insight into asset health, you can find which assets require attention.
- **Key IWInfra capabilities** - A single, user-friendly mobile-first app offers an overall view and health drill-down, with sensor data integration, health-based notifications and actions, and flexible health scores by type or group of assets and informed asset health benefits.
- **Decreasing asset failure costs and frequency** - Registered IoT devices and encryption compliant data channels monitor asset conditions. Consequently, sensor data is sent, triggering automated actions helping to reduce costly failures.
- **Boost asset availability** - Track conditions, costs, performance, and remaining useful life, reducing asset breakdown and inactivity.
- **Preventive maintenance efficiency** - Combining asset knowledge and sensor data, actions are based on asset health, and preventive maintenance is used efficiently.
- **Operational risk limitations** - Offering an in-depth assets' status vision aids in focusing on the assets that require immediate attention. Therefore, operational risks are reduced.
- **Capital replacement decisions** - IWInfra allows reducing times for replacement, as planning is more accurate because of powerful analytics that provides a clear view of assets' conditions.

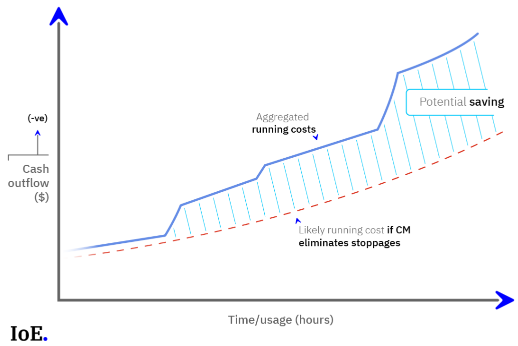


Figure 5 - *Potential saving via the implementation of IWInfra predictive maintenance.*[2]

IWInfra's security beyond cyber

Critical infrastructure data is one of the main targets for cyber-criminals, and due to the rise of IoT deployments into all industry verticals, risks increase exponentially. Cyberattacks on city infrastructure are not rare, and the consequences are life-threatening and costly, a reality that comes from:

- "One of the major issues for industries such as gas and electricity is the vulnerability of the SCADA-based systems that power CNI, which were never meant to be connected to the internet."[3]

The IWInfra acts upon the cybersecurity problem by developing a device-cluster, decentralized software infrastructure, blockchain-secured, and with a knowledge-based AI to keep data, storage, analysis, processing, and delivery at the source. IWInfra offers security beyond cyber, resulting in service, capable of predicting maintenance by providing data to information refinement without connecting to the Internet, e.g., cloud service providers.

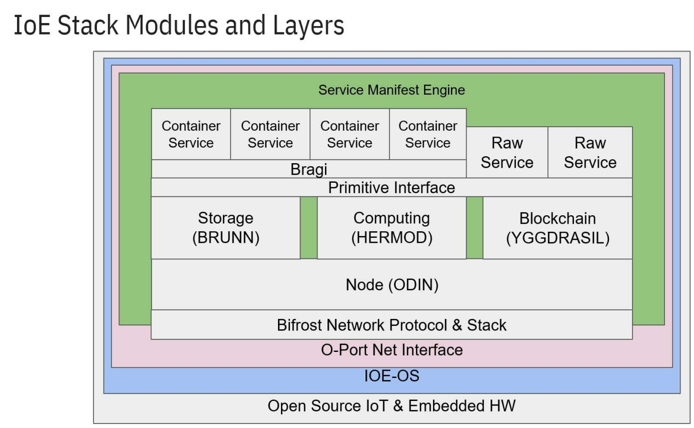
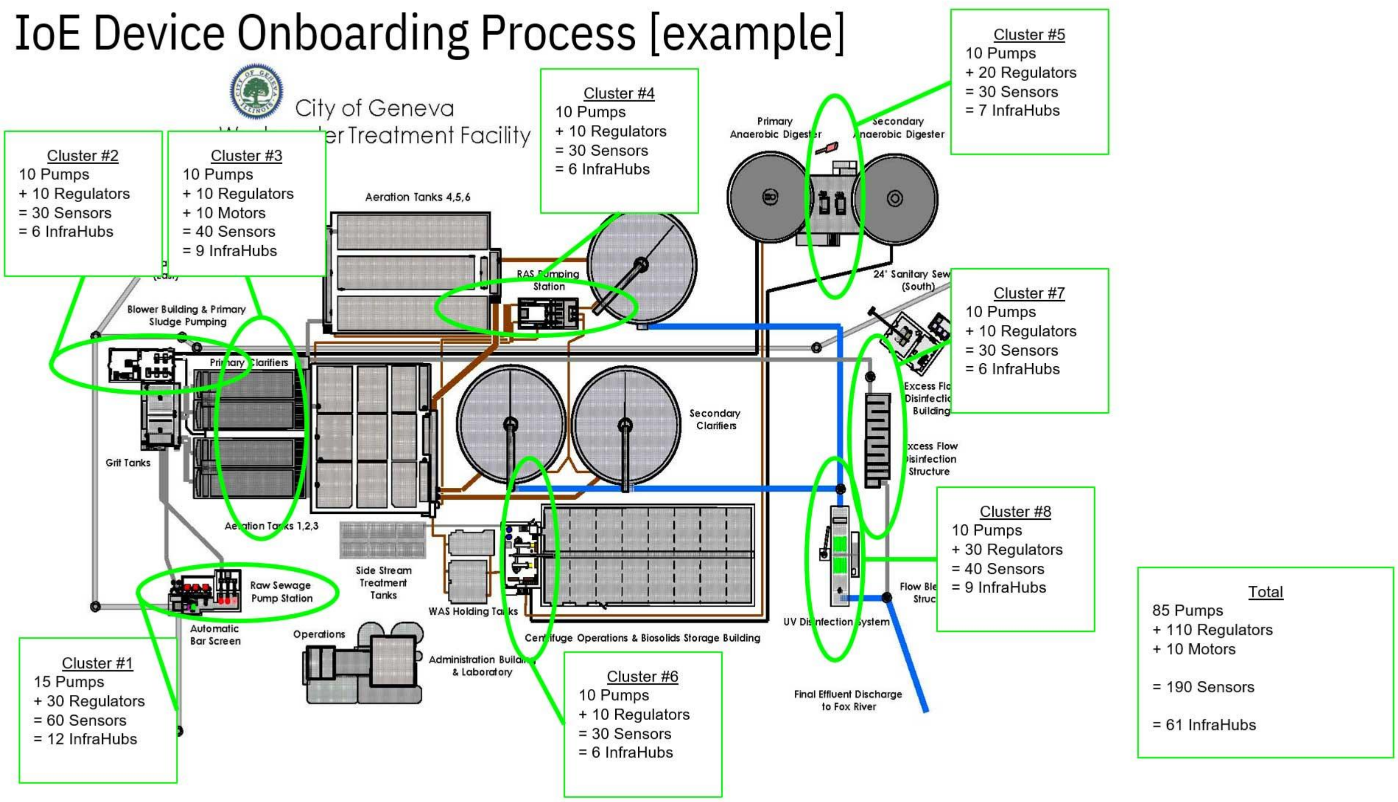


Figure 6 - *IoE IWInfra modules and layers for predictive maintenance.*

Graphic description

See how IWInfra asset Prescriptive Management on Private Garden Cloud uses predictive maintenance to help drive cost savings and operational efficiency:



Conclusion

Instead of having to do all the unnecessary maintenance work that comes with preventive maintenance, competent predictive maintenance merges raw data from IoT and instrumentation with AI-measured analytics through digital networks.

With IWInfra any wastewater company can identify and manage asset reliability risks that could adversely affect plant or business operations. Therefore, implementing IoE Corp's IWInfra, reduces exponentially the cybersecurity risks and the high investment costs that digitization accounts for, changing the thoughts of decision-makers in the Water and Wastewater Systems (WWS) try to avoid digital.

Another aspect of minimizing risks is that since IWInfra doesn't run on the WWW, it is not vulnerable to cyberattacks. The decentralized system of nodes works together through a blockchain and controls each other. They all share parts of the overall data, and there is no central point of attack for a cyber-criminal. Instead, security beyond cyber is created.

The IWInfra system is made possible to be secured by the use of IoE Eden Private Garden Cloud Technology that, in its essence, creates cost-effective, easy to manage & maintain standalone IoT clouds.

References

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2. R. Keith Mobley, *An introduction to predictive maintenance*.—2nd ed., 2002 https://www.irantpm.ir/wp-content/uploads/2008/02/an-introduction-to-predictive-maintenance.pdf

3. Kate O'Flaherty, *Critical National Infrastructure: The Growing Threat,* Info Security, 7 July 2021, https://www.infosecurity-magazine.com/magazine-features/national-infrastructure-threat/.