White paper

Enhancing Water Network Efficiency

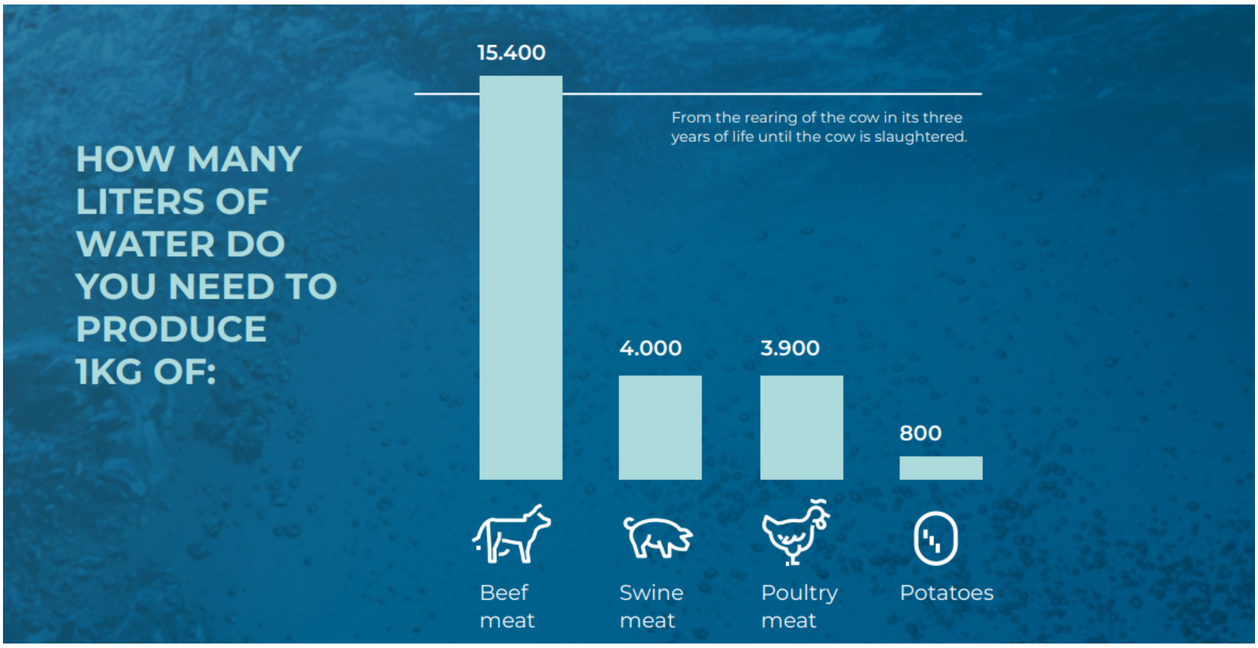
Innovative Approaches to Water Network Management: Enhancing Leak Prediction and Prevention

sensoworks

SUMMARY

1. Acknowledgements

According to economic theory, the value of a good is determined by the scarcity of the same, that is the gap between limited resources and unlimited needs. There is no doubt that humans use water as if this was unlimited: it is estimated that about 80% of all industrial and urban wastewater is released into the environment without prior treatment.



But fresh water is becoming more and more scarce, day after day. More than two billion people already live in water stressed areas. About 3.4 billion people, 45% of the world's population, lack access to sanitation facilities that are managed safely. According to independent assessments, the world will face a 40% global water deficit by 2030. This situation will be exacerbated by global challenges such as COVID-19 and climate change.

The goal of this white paper is to show how an IoT platform integrates with the founding principles of the circular economy to provide an excellent all-round solution for strategic drivers. Sensoworks' IoT platform in particular, not only can communicate with smart devices across the installed network, but it can also trace all the incoming and circulating information back to the "City System", so as to optimize all its outputs.

If this work of ours helps you and your company better understand what your organization needs and where to direct your efforts, we will have achieved our key goal.

Hold fast,

Niccolò De Carlo
CEO and co-founder of Sensoworks

2. What is Sensoworks

Sensoworks is an innovative IoT solution that combines a powerful IoT platform with advanced edge computing software to revolutionize the monitoring and management of water networks. This comprehensive solution allows water utilities and municipalities to proactively monitor their water infrastructure, predict and prevent leaks, and ensure the efficient and sustainable operation of their systems. This white paper outlines the features, benefits, use cases, and implementation of Sensoworks, highlighting its potential to transform the way we manage water networks. Sensoworks is designed to address these issues by leveraging IoT technology, providing real-time monitoring, and enabling data-driven decision-making.

3. Our vision

As technology advances, devices and systems will become more advanced and sophisticated, with the ability to gather and analyze data, understand and respond to human behavior, and even predict and take actions to meet human needs. This can lead to more personalized and tailored experiences for users, and a more efficient and effective relationship between humans and technology.

The ability for humans to empathize with objects through the use of technology can have a significant impact on society by creating more efficient, reliable, and sustainable infrastructures and systems. For example, by using sensors and monitoring water pipelines to gather data on the maintenance status and predict future leaks. Sensoworks allow humans to gather data from a variety of sensors and devices. This data can be analyzed and interpreted in real-time, providing humans with a more comprehensive understanding of the object's condition and performance, and enabling them to make more informed decisions about the object's maintenance and repair.

4. The water resources and its infrastructure

A) Water demand and use

Global use of fresh water has increased sixfold in the last 100 years and continues to grow at a rate of about 1% per year since the 1980s (AQUASTAT, s.d.), mainly in the majority of emerging economies, as well as in low and middle income countries (Ritchie and Roser, 2018). The principal factors influencing the current growth in water demand are mainly the growth of the population, the developing economy, and the changing consumption patterns. Agriculture, which includes activities such as irrigation, withdrawal of water for livestock, and aquaculture, is responsible for 69% of global water withdrawals. This ratio can be as high as 95% in some developing countries (FAO, 2011a). Industry (including generation of electricity and energy) is responsible for 19%, while municipalities are responsible for the remaining 12%. However, most authors agree that water use for agriculture will face increasing competition in terms of demand from industry and energy sectors, but also from municipal and domestic uses, mainly as a function of industrial development and improved coverage of water and sanitation services in developing countries and emerging economies (OECD, 2012; Burek et al., 2016; IEA, 2016).

B) Availability of water

Water stress, measured essentially as the use of water as a function of available resources, affects many parts of the world. However, water stress, defined as a condition, temporary or prolonged, of the absence of water, usually lacking at ground level, is often a seasonal phenomenon rather than an annual one. Four billion people live in areas that suffer from severe physical water scarcity for at least one month per year (Mekonnen and Hoekstra, 2016). According to the World Resources Institute (WRI) report, which measured the demand and availability of water in 167 states, the water emergency will be one of the most serious problems affecting our planet, not only in the poor areas but also in the more developed ones. By 2040 there will be as many as 33 states that will have to face “extreme” water stress: among them, about 14 are located in the Middle East area, with serious risks of political instability, but the scarcity of water will also be felt in other parts of the wor- ld including even in some areas of Italy and the Balkans.

C) Water quality

Due to the lack of monitoring and communication, especially in many of the least developed countries, data on the quality of global water remain scarce. However, some trends show how water quality has deteriorated due to pollution in almost all major rivers in Africa, Latin America, and Asia. Globally, it is estimated that 80% of all industrial and urban wastewater is released into the environment without any prior treatment, with harmful effects on human health and ecosystems. This proportion is much higher in less developed countries, where sanitation services and wastewater treatment facilities are severely lacking (WWAP, 2017). Poor management of agricultural runoff is considered also one of the most widespread critical issues related to water quality (OECD, 2017a).

D) Values of the overall benefits of the hydraulic infrastructures

Water quality for society is determined by the hydraulic infrastructure that is employed to capture, store or transport it. Hydraulic infrastructure provides significant social and economic benefits. The socio-economic development is limited in those countries that lack sufficient infrastructure to manage water. Approximately 1.6 billion people face water scarcity “economically”, which means that while water may be physically available, they lack the infrastructure needed to access that water (Comprehensive Assessment of Water Management in Agriculture, 2007). By 2030, investments in sanitation and water supply infrastructure will have to be about 900-1,500 billion U.S. dollars per year, about 20% of the total requirement needed for all types of infrastructure investments (OCSE, 2017b). About 70% of total infrastructure investment will be in the Global South, with a large share in urban areas undergoing increasing development (GCEC, 2016). In developed countries, there will be considerable investment needed for restructuring and upgrading.

5. The sustainable transition of the hydraulic system

Transition to a circular economy model in water use

It is well known that water underlies most of the aspects of economies and sustainable development. Water scarcity is already a serious problem for several states in the world. According to data released by the Intergovernmental Panel on Climate Change (GIEC), water availability will be seriously affected by climate change. The increase of one degree in the Earth's temperature corresponds, according to scientists, to a 20% reduction in the availability of water resources. It means that, in the absence of decisive measures, by 2030 global water availability could be reduced by 40% compared to today. According to the European Commission, at least 11% of Europe's population and 17% of its territory have
been affected by water scarcity. During the summer season, more than half of the population in the Mediterranean region is affected by water stress. The most recent reports from the European Commission and major international organizations emphasize the need to develop appropriate measures aimed at facilitating the transition from the linear economy model, currently prevailing, toward a circular economy model capable of enhancing the efficient use of resources. This need is universally recognized as particularly pressing for water, an indispensable resource for life and all human activities. In addition to the irrigation reuse of water, the circular water economy aims for the sustainable recovery of material resources and energy contained in wastewater, helping to reduce greenhouse gas emissions and the ener- gy consumption of existing wastewater treatment plants. Managing water resources from a circular perspective requires interventions at different stages of the cycle. The first line of defense against water scarcity should be a demand management strategy global (for drinking, irrigation, industrial, and energy) that promotes sustainable lifestyles and sustainable production and creates concrete incentives for saving, conservation (counteracting the dispersion in distribution networks) and resilience of water sources and related water infrastructure for derivation and transportation. A second aspect, still little explored, concerns the enhancement and use of unconventional water resources (mainly purified urban wastewater).

Wastewater management from a circular economy perspective means the reuse of purified water, mainly in agriculture, and implies sustainable recovery of material and energy resources contained in wastewater, thus transforming sewage treatment plants into biorefining plants that convert waste substances into useful products, such as biogas and biomethane, fertilizers (nitrogen, phosphorus), organic substances (cellulose, polyhydroxyalkanoates used in the production of bioplastics). For wastewater reuse, attention must be paid to the prevention of pollution at the source through the prohibition or timely control of the use of certain contaminants; to the collection and treatment of wastewater in an effective and widespread manner; to the refinement of wastewater and its distribution to make it an alternative source of water, safe and economic, both for irrigation and for industries and the environment; to the possibility of recovering energy and materials present in urban wastewater, such as nutrients like phosphorus and chemicals such as biopolymers or cellulose, which can be reused in industry or agriculture. For optimal management and valorization of wastewater in terms of a circular economy, treatment processes and methods of disposal, and reuse of sewage sludge, are important. Sewage sludge should be defined concerning its characteristics and the territorial scope of reference (Critical Raw Materials). Phosphorus is indeed a critical raw material for Europe, because of the almost total reliance on imports from countries outside Europe and the very low rate of recycling from end of life products.

6. The digital revolution in water service

The water utility has in recent years started its digital transformation journey. However, the adoption of digital technologies is still at an early stage, and for it to fully express the wide potential benefits, it should be supported with concrete actions on several fronts: regulatory, normative, and financial. The combination of digitization and Water Service Integrated is set to grow stronger and stronger.

How digital can support the protection of the environment

Digital technologies are transforming many aspects of the world we live in, from industries to cities, to everyday life. Digital transformation is among the great forms of disruption, global evolutionary trends destined to change the way things are done, to revolutionize industries, including integrated water service. The concept of "Industry 4.0" understood as "a strategic approach to the integration of advanced Internet based control systems that enable people and machines to connect anytime, anywhere, with anyone and anything in a single complex system" was first introduced in Germany in 2011 and declined by the German Water Partnership (GWP) for the Integrated Water under the erm "Water 4.0." These are terms that describe the industrial digital transformation characterized by the advent of smart devices and the availability of data for effective decision making, combining both the physical and virtual worlds in the cyber physical systems (CPS) of the Internet of Things (IoT) and Internet of Services (IoS). A major paradigm shift that leads to talking of a fourth industrial revolution. ICT (innovation and communication technologies) is the key to improving water resource management, enabling the development of intelligent monitoring, management and measurement systems, knowledge decision support, and also greater awareness of water consumption and value. In the area of internal processes and infrastructure, the use of digital technologies revolves around the use of data to optimize decision making processes, streamline service management and improve quality. This is made possible by the so called "cyber infrastructures", ie data collection systems, sensors and instrumentation and storage, processing, and display of the same (smart water network, IoT, data-science techniques, augmented intelligence, blockchain) They allow you to make more informed decisions in real time. The adoption of remote sensing (e.g. sensors, satellites) and asset management technologies enable water utilities to benefit from immediate knowledge of their network and plant systems through detailed measurements, continuous monitoring of processes and infrastructure involved, as well as automating some processes and taking remote action. It is a useful aid in the prevention of service interruptions and water leak detection. Effective knowledge of the physical and operating conditions of networks and systems also makes it possible to direct investment spending toward real priorities, plan interventions accurately even in the medium to long term, and optimize maintenance based on knowledge of the state of networks rather than their usefulness.

Cognitive analytics based technologies enable value to be derived from data, guiding decision-making toward the best action with predictive and prescriptive algorithms, predicting potential failures, and automating processes and choices. These applications on physical assets must necessarily complement an appropriate degree of digitization of internal processes: Enterprise Resource Planning systems, Workforce Management, Customer Relationship Management, Project Management, and E-Procurement. Tools needed for utility innovation water utilities and their efficiency (of time and workloads) through the computerization of information flow circulating within them.

The new opportunity created by water 4.0

Given the nature of monopoly service that characterizes water service, the relationship with the user becomes a key strategic asset to convey the role and spillover effects of its operations in the relevant territory. In more recent years, there is a growing need to strengthen the relationship of trust with the citizens. Digitization in user relations offers a unique opportunity to create engagement greater, made of transparent communication and immediate, simplifying the completion of end to end administrative practices. Through notifications from digital applications (Apps) and instant messaging, communication can be made more immediate, smooth, and direct. Notices of service disruptions, outages, and scheduled resets, as well as information on open construction sites and initiated work, can be communicated in real time, as can outcomes resulting from unpredictable events. Online services and personal web user areas can facilitate supply management through user self managed procedures, sending self readings and complaints, activating practices and services such as web billing or booking appointments, as well as making users more aware of their consumption and the quality of tap water (organoleptic properties and its healthfulness), reassuring them that they are consuming an environmentally preferable resource. In one stroke, this privileged relationship has beneficial effects on the internal organization of the Water Company, simplifying administrative and user management processes; on the other, it allows for a more conscious use of public water, saving the entire society concerning the lower use of bottled water with its lower impacts on the environment. Users' expectations of sustainability are already changing their behavior: the more water service will rely on digital assets, the more users will be able to participate as prosumers in the conservation and reuse of water. In this transformation, one of the first opportunities for water service operators is the implementation of the so-called digital twin, the digital representation of the infrastructure that makes up the water system, whose information can be used to plan interventions of optimization and efficiency. This scenario sets the stage for the application of data science technologies, including those based on artificial intelligence, big data analysis, machine learning, and deep learning, which can help address two main needs.

The first need: derive value from data and perform or automate in a predictive and prescriptive manner. Basically, not only monitor the water system, but provide, for example, decision support, automated control, risk prevention, and preventive planning.

The second need: is to process and manage large amounts of data from different sources (different components of the network or treatment plants), reducing the time needed to process them, as well as the risk of errors and delayed decisions.

7. The digital applications in the integrated water system

Consumed focused services

- Improved experience in dealing with Customer Care (complaints, information, feedback of intake, and resolution of problems)
- Transparent and immediate communication, simplifying the completion of paperwork administrative (activation, vulture, termination)
- Online desks and personal web user areas to facilitate supply management through user self managed procedures
- Tips on water saving in the household

Benefits in the relationship with users' customer experience

- Increased satisfaction with service
- Simplification and speed for the completion of practices
- Awareness of customs and proactivity in reducing them
- Increased user involvement and responsiveness to their requests

Dedicated services for managers

- Increased satisfaction with service

- Simplification and speed for the completion of practices
- Awareness of customs and proactivity in reducing them
- Increased user involvement and responsiveness to their requests

Utilities

- Focus on affordability
- Increased resilience to climate change
- Public safety
- Improved service quality and environment protection

Benefits for the community

- Focus on affordability
- Improving the long-term affordability of the fee structure
- Greater transparency in the use of revenues of water tariffs

Long term resilience

- Increased operational flexibility in the face of climate and demographic changes
- Improved safety through rapid user involvement in case of public health risks
- Easily test and adopt cutting edge technologies

Improved quality of service to protect the environment

- Reducing the risk of an overflow of wastewater into the environment
- Reducing greenhouse gas emissions
- Improvement of conservation and management of resources
- Reducing the risk of water quality non compliance
- Increased service continuity

8. The role of the technology in the efficiency of the supply line

Obsolete infrastructure along with the inefficiency of the water system necessitates massive investment in technology to improve service. The Value Water Community has identified 4 pillars for water sector efficiency:

- Minimize the use of fresh potable water for activities and sectors that might use non potable water;
- Increase recycling and reuse of water and wastewater;
- Reduce the production of wastewater from the extended water supply chain;
- Efficient monitoring systems to keep consumption under control by adopting energy efficiency policies.

The management of scattered water networks is complex. Many of the components of the networks' physical system are not easily accessible such as pressure or flow sensors. The convergence of IT (Information Technology) and OT (Operation Technology) is vital. The intersection of IT and OT alone, however, is not enough, which is why enabling technologies such as mobility, connectivity, and IoT need to be implemented.

Hydraulic modeling solutions, and their digitalization, enable accurate simulation of performance at key points in the network. Virtual sensor techniques make it possible to calculate flows and pressures where real sensors cannot be included.

To make water networks resilient, efficient, and sustainable, it is essential that management, monitoring, and control are automated (including the remote ones). The goal is to respond in real- time to water demands and, to ensure the safety of plants and the water delivered itself, by moving to a service based on predictive instead of reactive systems.

To be efficient you need data; to manage, analyze and return it understandably, you need software and digital services: from reactive systems to predictive systems.

The digital transformation of the industry will ensure, including through artificial intelligence systems, cyber safety, and new technologies, a digitalized and efficient "smart water" system.

9. The role of big data and IoT in water management, predictive analytics

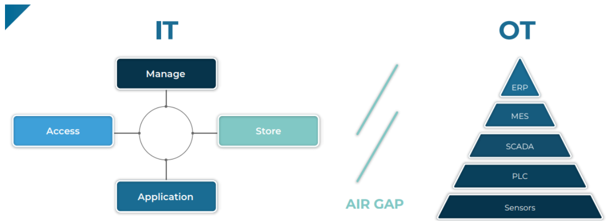
Another aspect of digital transformation, the Industrial Internet of Things (IIoT), allows various control systems, such as sensors, to be accessible throughout the network and connected anytime, anywhere. This implies that water companies engage in two fundamental actions:

- Equip resilient and efficient Safety systems to ensure that all parts of the infrastructure are protected from cyber attacks;
- Having a digital structure that can collect, process, manage, and return an ever increasing amount of data in an easily readable manner.

More quality and better managed data can increase the efficiency of the entire network, use less energy, anticipate and reduce outages: and as a result, services for citizens will be improved.

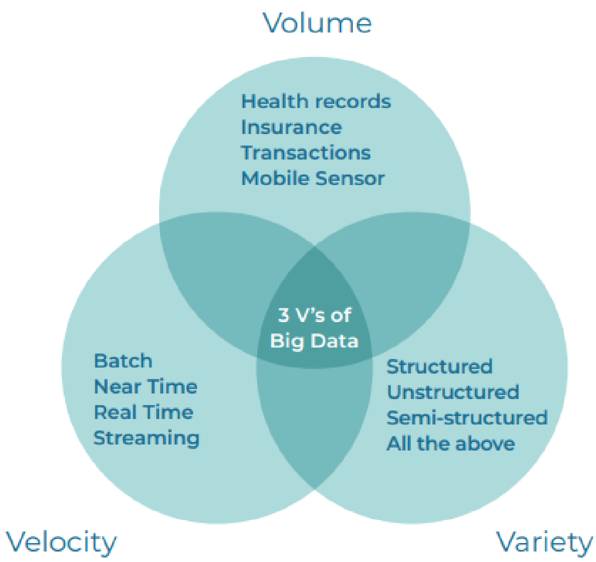
We often talk about Smart City: in the case of water, "Smart" is about making water supply and distribution smart with the Internet of Things (IoT) technologies, so that it can connect and communicate with other parts of the system and the city.

Smart water systems use IoT activated sensors to collect real-time data and generate the so-called "digital twin" of the physical infrastructure on the ground and enable its modern and optimized management. This enables optimization of water



facilities by detecting leaks in the network, leaks to utilities, flow rates, pressures, or control of water distribution on the network and enables operators to make more informed decisions about water resource management. The processes currently used in many water services for the district and water networks are based on a growing awareness of resources and increasingly refined processing of data that generate.

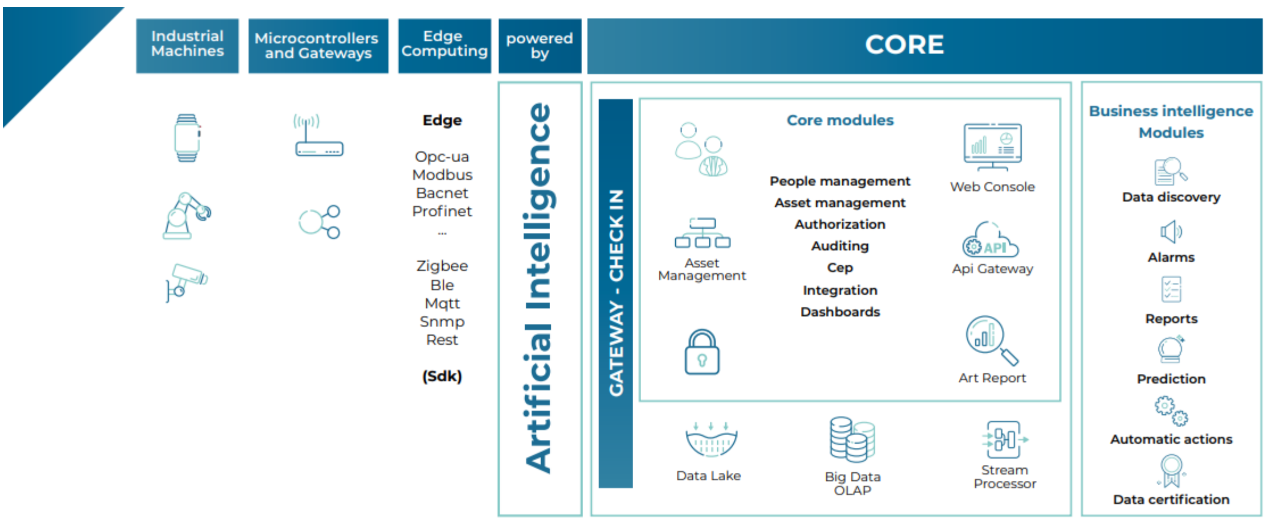
With Integrated Solutions, leaks in pipelines can be detected, the behavior of networks can be predicted in the face of future expansions, new allotments, changes in operating pressure or pipeline diameter, etc., and structural problems can be identified in advance and adaptation investments can be planned accurately and on time.



Such data are even more valuable when they're shared: watershed management teams, for example, can use predictive technologies to understand when and in which areas a greater likelihood of flooding exists before it happens. Transportation managers,

by sharing this information, can warn people about the risks and divert traffic. The predictive intelligence made possible by IoT and big data will have a huge impact on cities, saving time and conserving resources.
These facilities, connected and integrated through IoT native, will result in significant water savings by reducing losses due to malfunctions and ruptures. In addition, they will result in bill savings for the private citizen and a reduction in waste, a fundamental issue in an increasingly populous world that, until now, has treated natural resources as if they were infinite and guaranteed. They will also enable private citizens to save money and reduce waste, a key issue in an increasingly populous world that, until now, has treated natural resources as if they were infinite and guaranteed.

demand for drinking water is not fully met, at least in some areas.
This inconsistency is due in part to the continuous increase in water demand, linked to economic development and higher quality of life, and in part to a series of structural, managerial, and maintenance (ordinary and extraordinary) deficiencies in water systems that result in significant losses representing, in Italy, 40% of the resources withdrawn from the environment (latest data provided by the Committee for the Supervision of the Use of Water Resources).
This is water lost from the adduction and distribution networks and, consequently, already equipped with hygienic and organoleptic requirements suitable for human consumption.



From reactive to predictive management

The leakage problem greatly plagues water systems that are inefficient and unreliable.
Analyzing the water infrastructure sector and, in particular, the water services sector, it appears that although our country is rich in water overall, the

Water leaks from pressurized water pipes are very sensitive because any leaks, in addition to causing economic damage from wasted water, risk far more serious and dangerous consequences including seepage, landslides, flooding, or land subsidence.
Recovering an aliquot of the significant volumes of wasted water would both alleviate the problem of the

frantic search for new sources of supply initiated by the utilities and save costs from addiction and treatment. All this, together with the indications of the legislation concerning the water resources sector, has raised the awareness of operators towards the issue of leakage, resulting in the development of studies aimed at estimating, controlling, and, therefore, reducing it. In particular, operators and multi-utilities have decided to focus on predictive maintenance. The goal is to identify the points in the infrastructure where network failure is most likely. This makes it possible to intervene with the replacement of the pipeline at risk before the damage occurs. To this end, artificial intelligence algorithms are being tested precisely to identify the highest risk spots so that investments and interventions can be planned in an increasingly timely and targeted manner.

The basic idea is to develop an artificial intelligence algorithm with "supervised learning" and "dynamic weights."
In supervised learning, the network is given a set of inputs (training set) to which known outputs correspond. By analyzing them, the network learns the connection between them. Thus it learns to generalize, that is, to compute new correct input-output associations by processing inputs outside the training set. As the machine processes output, it is corrected to improve its responses by varying the relative weights (dynamic weights) to the connections between nodes.

The algorithm starts from the study and analysis of the factors endogenous (age, material, and diameter of the pipeline) that can determine the rupture of a pipeline, and then goes on to identify the acoustic characteristics of the signals recorded by the accelerometers installed near the pipelines. The "training" phase of the algorithm includes the input, for the neural model, of power spectra calculated through the application of the Fast Fourier Transform to the acceleration time histories recorded in the case of real losses.
In the absence of the dispersion noise signal, there is generally no significant energy change in the spectrogram, and the flow noise energy is distributed almost evenly.
In the presence of leaks, on the other hand, it is possible to see a noticeable change in the distribution of energy in particular bands which indicates with good certainty the presence of ruptures within the pipes. Spectral analyses then allow for the detection of the predominant frequencies (frequency peaks) identified in the event of a leak; these peaks will naturally be a function of several parameters related to the type of rupture (shape, bore, etc.), size, geometry, the material of the pipe where the leak occurred, velocity and pressure of the fluid, and the presence of catchments or pumps near the point of rupture.
Once the neural model training activity is completed, the training data can be compared with the data collected in the field to detect and classify any incidents.

Many things can be done to improve and maintain high levels of service and customer satisfaction. An integrated water network management systems can identify problems before they occur. In this way, both those who manage and those who use the water network can be informed of potential problems in a proactive way.

10. The safety and management of water networks (physical and cyber)

Internationally, most water utilities in industrialized countries are beginning to consider cyberSafety as an integral part of their modernization process. However, the level of cybersafety in water networks does not correspond yet to the level of risk faced by the entire sector. In developing countries, however, cybersafety is not at all a priority for water utilities.

The challenges in these areas are diverse: water shortages, water treatment, distribution network efficiency, wastewater disposal, etc. And when it comes to inequality and scarcity, conflicts naturally arise over control of this vital resource. An economic and political situation that is now a breeding ground for cyber attacks. Today's water infrastructure depends on geographically distributed architectures and remote maintenance of systems.

Maintaining the integrity of exchanged commands and data is therefore essential to ensure the quality of this resource until the end of the distribution chain. The water industry has no choice but to think about how to secure its systems if it wants to optimize its water treatment and distribution processes in an IoT or IIoT. To this end, the industry mostly adopts strategies of segregating each of its facilities by separating the IT world (PCs, servers, users) from the OT world to isolate the operational part of the supply chain in case of attacks. However, especially in this area, "universally valid" solutions often prove insufficient.

To ensure the cybersafety of water networks, it is necessary to constantly verify the reliability and legitimacy of data and commands transmitted via both network and OT protocols in real-time. Two extremely relevant issues emerge such as the PSA (Piano di Sicurezza delle Acque, "Water Safety Plan" in English) and Water Leakage Management.

Regarding the first point, the PSA, the World Health Organization has for more than a decade introduced the model of Water Safety Plans as the most effective means of systematically ensuring the safety of a drinking water system, the quality of the water supplied, and the health protection of consumers, users, and citizens.

In Italy, there are still few aqueducts that have been equipped with a PSA, and the Ministry of Health, through Istituto Superiore di Sanità, has made available documents and experts who actively deal with this issue. The industrial landscape is changing rapidly and in a deep way: economic challenges, information overload, staff training or the intrusion of new technologies, the proliferation of intelligent systems and devices, the extensive use of process data, and data versus time and time series.

The visible effects concern the consolidation of systems, the increase of IT influence, skills in vertical sectors, Cloud and operational mobility, faster adoption of technologies, and the use of social media. And in this context, systems of HMI/SCADA control and remote control are changed.

Just think about the role played by the controls room. Until yesterday there were important physical places of operational knowledge, towards which the information flows from different sources and within which the Staff gathered to analyze the data. Today and increasingly in the future – thanks to mobile devices, connectivity and cloud services will be intangible spaces, which geographically distant subjects can access at any time and from any place. The paradigm shift is evident: the continuous availability of data, even sensitive ones and the possibility of operating at any time and from anywhere bring enormous advantages, but also equally great risks if you do not take the appropriate precautions. And this is valid for mobile devices that are configured as the elements through which you access information and operate whether for those tools such as sensors, actuators, or communication protocols designed before the Internet era or at an earlier stage when IT risk was much less compelling. Thinking about addressing the safety issue of industrial systems with the same the approach used so far in business solutions would be a mistake. If in the field of IT (Information Technology), the basic principles of cyber safety define secure data when the CID (Confidentiality, Integrity, Availability) criteria are met, in an OT environment (i.e Operational Technology, which represents the set of all “intelligent systems” that manage plant information), the order of these three factors must be read in reverse: the essential characteristics are Availability and Integrity, while Confidentiality is almost an accessory parameter. A system must be functional at first, moreover, considering the use of the system itself (more or less critical), it has to allow the Fault Tolerance. This means having hot redundant systems, working in parallel, and a minimized start-up time.

Data Integrity, however, can only be achieved by adopting software solutions designed and developed to ensure reliability in the data management chain, complete access traceability, and accurate registration (possibly also with systems of a double electronic signature or similar) in case of changes or correction of data or values (also with a log and Audit). A logical consequence of these principles is that integrated solutions must be used in the industrial field specifically designed for this purpose. The best approach for achieving an effective and functional protection system is now defined as holistic or capable of looking at cybersafety from a global perspective.

11. Case Study: Water leaks prediction

In the world of utility management, the efficient and reliable distribution of water resources is of paramount importance. For Italian water operator Gori, ensuring the seamless flow of water across its network is not just a duty; it's a commitment to providing clean and sustainable water supply to the communities it serves. In this case study, we delve into the challenges faced by Gori and the innovative solutions implemented to enhance the efficiency and performance of an 11 kilometer water pipeline.

Sensoworks comprises a central platform that facilitates data aggregation, analytics, and management. This platform acts as a hub for collecting and processing data from various IoT sensors deployed throughout the water network infrastructure. It ensures the security and reliability of data, providing a unified interface for network monitoring and leaks prediction.

To enhance real-time data processing, Sensoworks incorporates fog computing. This means that data processing and analysis can occur in the cloud infrastructure, not the same as the platform, ensuring critical events can be monitored rapidly and acquired data pre-processed before sending to the platform.

A) Key Features and Components

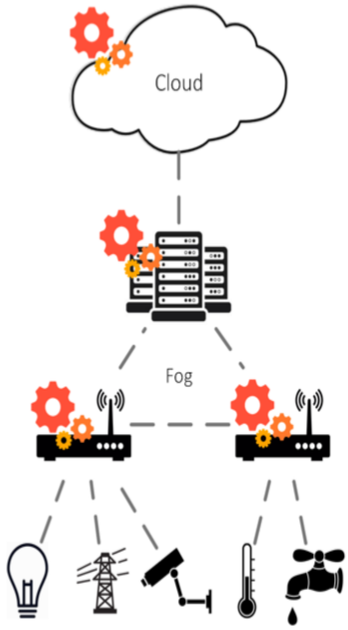
The project created for Gori aims to analyze the data coming from the data loggers and in particular the variations in the predominant frequencies recorded by the vibrophones.
The objective is to predict future losses based on the change in energy distribution in particular bands which indicates with good certainty the presence of breakages inside the pipes.

Real-time Data Acquisition

Sensoworks uses IoT sensors, vibrophones, to collect real-time data from each section of the pipeline where they are installed. This data is continuously transmitted to the central platform for analysis. Vibrophones record duct noise as an audio track.

Edge and Fog Computing

Sensoworks IIoT Fog is a component of the Sensoworks solution that performs most of its processing at the nodes and gateways of the network that connects them. In this project it is directly connected to each vibrophone to acquire noise audio track.



(c) Fog

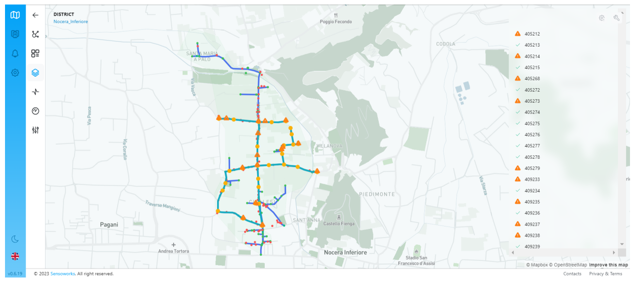
IoT sensors

Vibrophones from VonRoll Hydro have been used to record noise alongside the pipeline. In total, for the whole 11km of pipeline, we used 29 vibrophones.

Using the latest technology and various different measurement methods, the ORTOMAT-MTC leak monitoring system enables the locations of water leaks to be detected at any early stage.

GIS and dashboarding

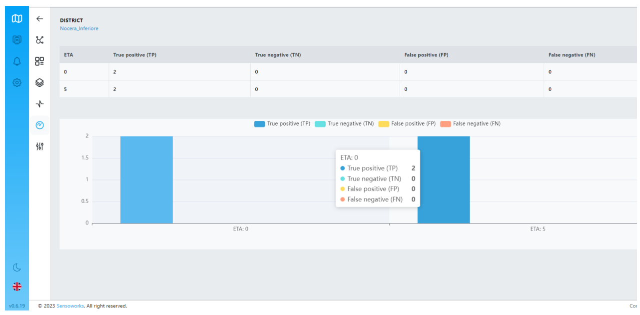
Sensoworks IIoT Platform employs advanced analytics and GIS maps to support users in accessing data acquired from the sensors. GIS layer shows where the sensors are installed and informs users about alarms and/or events. With data-driven insights, Sensoworks optimizes pipeline data collection in real time, adapting to changing conditions.



Water leaks prediction

Predictive analysis refers to the approach by which data, statistical and/or artificial intelligence algorithms are used to identify the probability of future events based on historical data.

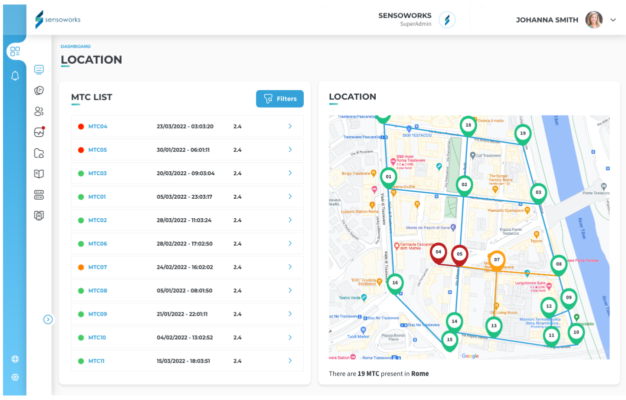
The algorithms implemented in Sensoworks for predicting future losses are based on the level of acoustic entropy of the signal and subsequent alert evaluated based on this level. Also considering the construction materials, geometry and dimensions of the pipeline.



At present the reliability percentage of the algorithm is 96% considering only the reports made by the manager, it may undergo variations depending on the findings in the field when we are able to fully identify any false positives.

Reporting and Analytics

Users can access detailed reports and analytics through the Sensoworks platform, aiding in decision-making, resource allocation, and performance evaluation.



12. Benefits

Sensoworks is not merely an IoT solution; it is a transformative tool for water network monitoring, delivering financial savings, environmental benefits, enhanced service quality, and strategic advantages for municipalities and water operators. It reflects a shift toward more sustainable and efficient water management practices while ensuring public satisfaction and a reduced environmental footprint.

Operational Efficiency: The strategies and technologies employed by the operator have significantly enhanced the operational efficiency of the 11km water pipeline, resulting in reduced downtime, improved water flow, and minimized disruptions to service.

Cost Savings: The operator's proactive approach to pipeline management has led to cost savings by optimizing maintenance and reducing non-revenue water losses, which is critical for any water utility operator's bottom line.

Enhanced Reliability: By addressing issues in real-time and predicting potential problems, the operator has improved the reliability of its water distribution network, ensuring a consistent and uninterrupted water supply to its customers.

Environmental Sustainability: The case study highlights the operator's commitment to reducing water waste and its environmental footprint. Through efficient water management, the company is actively contributing to water conservation efforts.

Data-Driven Decision-Making: The operator's adoption of data-driven technologies allows for better decision-making, helping the operator respond to network challenges promptly and effectively.

Community Satisfaction: Consistent water supply and fewer service disruptions lead to higher customer satisfaction and improved community relations.

Long-Term Viability: The case study illustrates the operator's forward-thinking approach to infrastructure management, positioning the company for long-term viability in the evolving landscape of water utilities.

Resilience to Challenges: The case study underscores the operator's adaptability and resilience in the face of unforeseen challenges, positioning the operator to navigate future disruptions with confidence.

13. Conclusion

This white paper wants to introduce the opposing concepts of linear and circular cities and economies, stressing on the reasons why circular cities are the only way to reach a truly sustainable world.
Just a few years ago, circular cities were abstract, utopical, something we could only write books and comics about. With the advent of new data transmission technologies, such as wi-fi and the optical fiber, the speed of data transmission increased exponentially and favored the development of 3G, 4G and, soon, 5G technologies. In these conditions, Sensoworks' IoT Platform finds fertile ground.

Before illustrating the applications of the Sensoworks platform, linear and circular consumption and economic models were described:
Linear cities represent the old economic model based on the exploitation of resources for mass production and production of massive quantities of waste.
This model must be replaced by the new circular model, based on sharing, optimization of consumption and recycling of waste. Sensoworks can play an important role for the organizations involved in this transformation.

How does a tech company like Sensoworks support this scenario?

Today, people want to know the benefits of a transformation of an investment. Otherwise, why should they change the model they're accustomed to? Public opinion has become increasingly sensitive to the problem of climate change precisely because the effects are increasingly evident.

Sensoworks makes the benefits of this economic and cultural transformation tangible, both in economic and environmental terms. Using appropriate sensors and through simulations and real time graphs, Sensoworks shows the convenience of this change.

Sensoworks works as a magnifying glass for every organization that follows a linear economic model but wants to convert to a circular model. It not only shows the final results, but constantly monitors the KPIs of every organization, so as to adapt to every environment and take corrective action when needed.

The modularity and flexibility that distinguishes Sensoworks makes it an ever evolving platform. Indeed, Sensoworks can act as a system integrator with a wide range of technologies, architectures and devices, and as an enabler for new, innovative city services.

Today, we still don't know the limit of its applications.

Sensoworks S.r.l.

Viale Giulio Cesare, 14
00192 - Roma
info@sensoworks.com
+39 388 8997263