WATER LEAK RISK MANAGEMENT

A WHITEPAPER BY SENSATIVE & AQUA-SCOPE

How to prevent water damage in your property

SENSATIVE

Aqua-Scope Technologies

Through the pipes, costly risks are flowing into your property

2%

Property owners expect water leak incidents in 2% of their portfolio, every year

€15.000

Average cost per water leak in MDUs in Sweden

US$25B

Annual pay-outs from insurance companies world-wide

US$80.000

not uncommon insurance deductibles in USA

Many dangers threaten buildings - fires, burglary, floods, earthquakes, tornadoes, or lightning strikes. However, one hazard is ten times more common than all other dangers combined; damage from pipes leaking water.

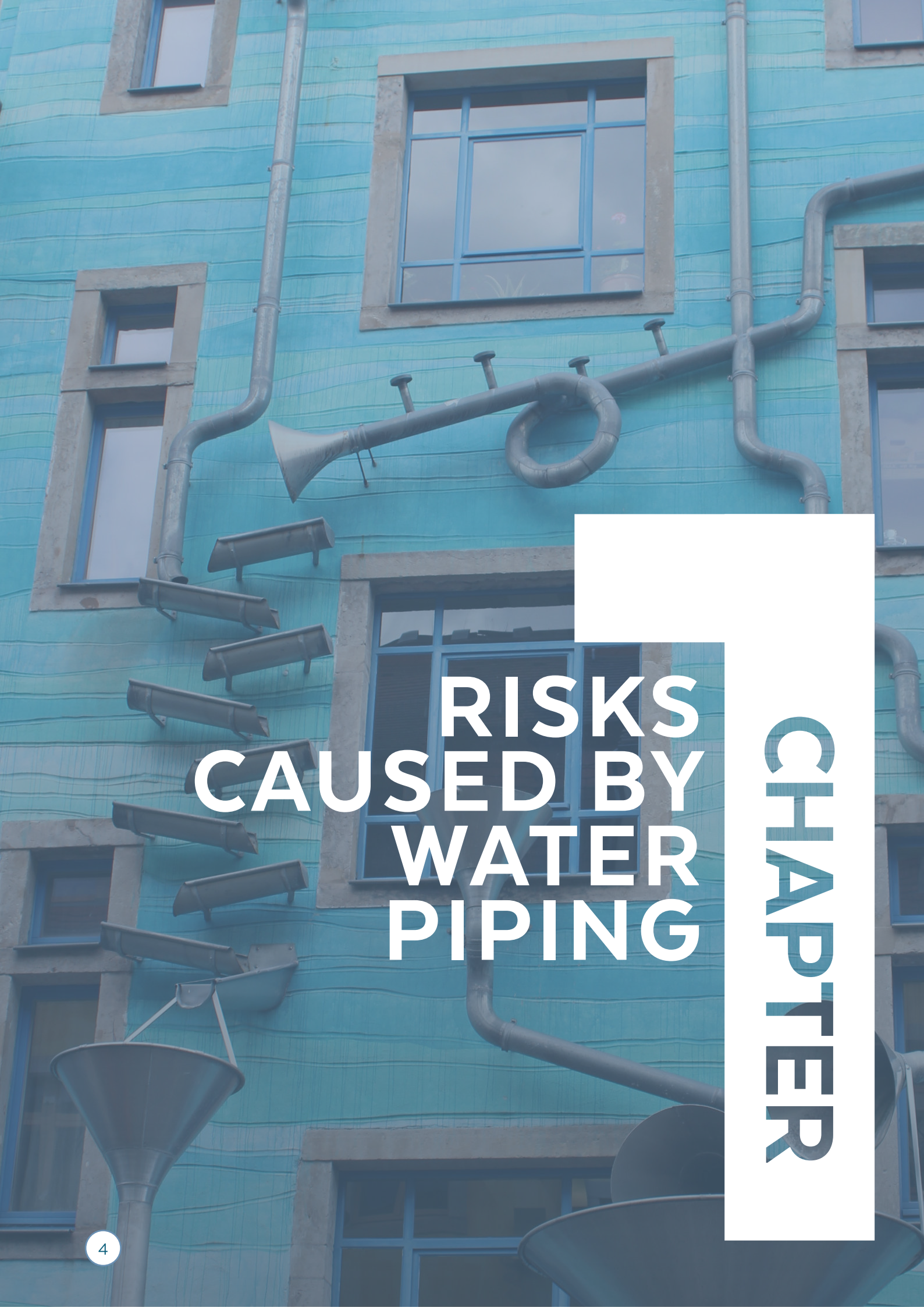
Insurance companies pay more than US$25 billion annually worldwide to regulate water-related damage to buildings and facilities. In Germany, as an example, it is more than €2.3 billion. This sum does not even cover the entire damage; on average, the insurance company only covers about 60% of the damage incurred.

The insurance costs and deductibles are rising, for some, significantly. In North America, US$80.000 - US$100.000 are now not uncommon.

Water damage is one of the main causes of mold growing on the walls and ceilings of a building, potentially causing health issues and severe damage to the property. Mildew and mold will develop within 24-48 hours of water exposure, and they will continue to grow until steps are taken to eliminate the source of moisture and effectively deal with the mold problem. This means treating with chemicals, replacing materials, and sometimes complete removal of structures.

To all these direct costs, you must also take into account the costs of business interruptions. You need to protect assets and act in real-time to catch adverse conditions like water leaks, but at the same time limit the number of staff on-site.

It is almost impossible for the tenants, businesses, or families to quantify the intangible damage caused by destroyed or damaged properties, lost memories, and personal inconvenience.



CHAPTER 1

RISKS CAUSED BY WATER PIPING

Risks caused by water piping

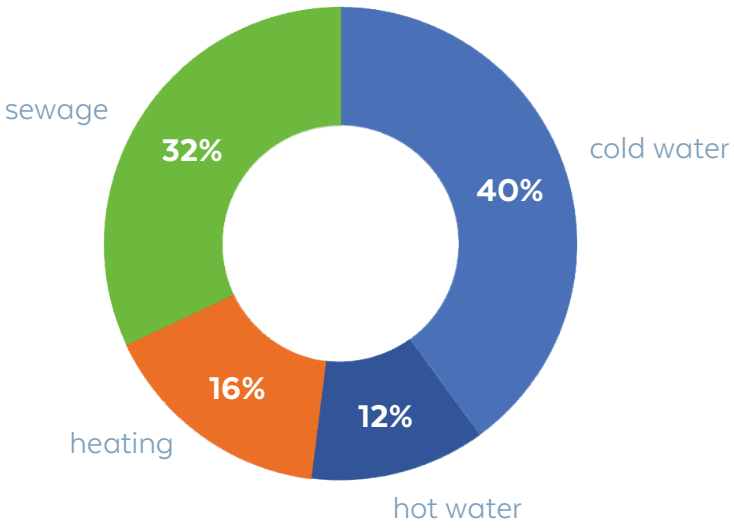
Water in the property can be divided into four areas:

1. Drinking water
2. Water in the heating system
3. Sewage
4. External water sources such as rain, ground, or flood water also damage the house. However, this damage is usually closely related to heavy rain events and, therefore, foreseeable, so we leave this outside this whitepaper's scope.

Drinking water

Drinking water continually flows from the outside through the main water supply. It is distributed inside the house via the house water distribution system to toilets and taps (for washbasin, shower, dishwasher, washing machine, bathtub).

Most installations connect domestic water distribution to hot water preparation, which distributes the heated water with or without a buffer water storage tank using a parallel distribution pipe system.



Damage caused by various systems
(Source: http://www.vattenskadecentrum.se/)

Water taken from the pipes or the hot water buffer tank is immediately replaced by freshwater from the domestic water connection. If there is a leak in the drinking water pipe, there is no inherent limit to the water flowing out. Furthermore, the water distributions are permanently under a water pressure of 2- 8 bar favoring leaks.

Water in the heating system

This is different from the heating water circuit. It is a closed system with a specific and limited amount of water. Leakage and water loss can also occur here. However, the pressure loss in the heating circuit that arises, as a result, is quickly recognized here, and the total amount of water that can escape from the system is limited.

Sewage

Sewage water is undoubtedly a danger to the building structure, especially if there is a leak over a more extended period. Sewage water is not under pressure and only flows when the drinking water supply has been used.

Insurance statistics show that only well under one percent of all water damage is associated with wastewater.

Because of the unlimited inflow of water under pressure, the drinking water distribution is the central component where leakage protection is needed.

Damage caused by water from piping can further be divided into two areas:

- **Malfunction**: This denotes leaks in the distribution, for instance corroded pipes, leaky connectors, or leaks in other faulty installations (warm water buffer tank, etc.).
- **Incorrect operation**: This includes the overflow of a sink, bathtub, or shower. Overflow usually occurs due to a combination of incorrect use, i.e., someone forgets to turn off the water and a partially or entirely blocked overflow on the sink or the bathtub. Showers can cause an overflow when the sewage pipe is blocked due to the mixture of soap, dirt, hairs, and other things that usually do not belong in a shower.

The insurance industry describes all events that lead to damage due to water in the house as "Escape of water."

The insurance industry, the primary victim of leaks, describes all events that lead to damage due to water in the house as "Escape of water."

How water can damage the building

Escaping water dampens building materials such as wood or insulating materials, softens and destroys furniture, clothing, books, and electrical and electronic devices such as TV or cell phones.

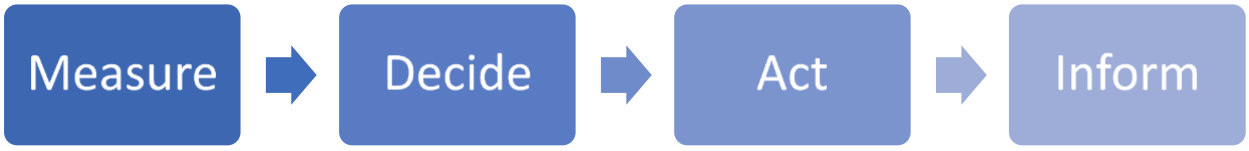
While water usually destroys electronic devices immediately, the damage to materials such as wood, paper, and textiles depends on the amount of water and exposure time. These materials swell due to prolonged exposure to water and therefore become unusable. Also, fungi and mold grow on the surface of wet organic materials, especially in combination with warm indoor air.

Even with a large quantity of leaking water, a quickly recognized water damage is therefore regularly less harmful than small but undetected amounts of water that could affect materials over a very long time.

CHAPTER 7

LEAKAGE DETECTION

Leakage detection limits escaping water, thus shortening exposure time of this water.
Leakage detection follows a process of four steps:



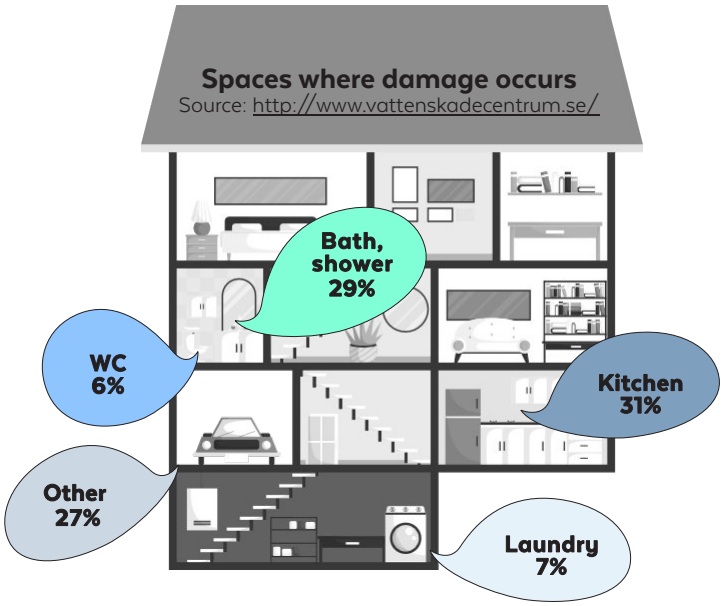
Effective leakage protection systems should adequately map all four sub-steps. However, products are also available on the market that only covers partial aspects of effective leakage protection.

Leaks can happen practically anywhere

A sound leak protection system must be able to identify all possible damage cases in a reasonable time. Damage cases can be of very different types and probability.

Typical incidents:

- Over the years, a copper pipe corrodes from the inside. The corroded area creates a small hole where a few drops of water can escape. Since the copper pipes are mostly installed inside the wall or on riser manholes, no one notices the small defect. Due to further corrosion, the hole widens, and the entire wall is moistened. When the damage is visible to the owner, it is usually too late.
- There is more frequent damage around the sinks. The flexible hoses between the corner valve and faucet leaks can tear off the corner valves due to thermal and mechanical stress.
- Pipe segments are connected with mechanical coupling elements, so-called fittings. Depending on the connection technology used, the soldering or pressing points on the fittings can tear off. This quickly leads to a considerable leak of water.
- Installations such as boilers, water storage tanks, instantaneous water heaters, or filters connected to the drinking water can leak. Water escapes at connection points or by rusting through the outer wall of the installation equipment.
- A jammed toilet flush does not leak water. However, adequate leakage protection will recognize this malfunction and warn against the unnecessary waste of water.



Sensors for Leakage Protection

Effective leakage detection systems must detect all of these cases and more using suitable sensors or a combination of sensors:

1. a sudden major water leak due to a pipe or other equipment being torn off
2. a more normal leak that leaks water over a more extended period
3. The permanent leakage of very little water through a so-called micro leak.
4. The overflow of water from the sink/bathtub due to misconduct by the residents.
5. Unusual water withdrawal, for example, from a jammed toilet.

Different sensors must be installed to identify all these types of damages and their measured values combined and evaluated.

Flood sensors

Flood sensors are small, battery-operated electronic devices that can detect water via external metal pins. If these metal pins are short-circuited, the electronics detect water and usually report this wirelessly to a control unit, which can then take appropriate actions such as switching off the water and/or alerting the resident.

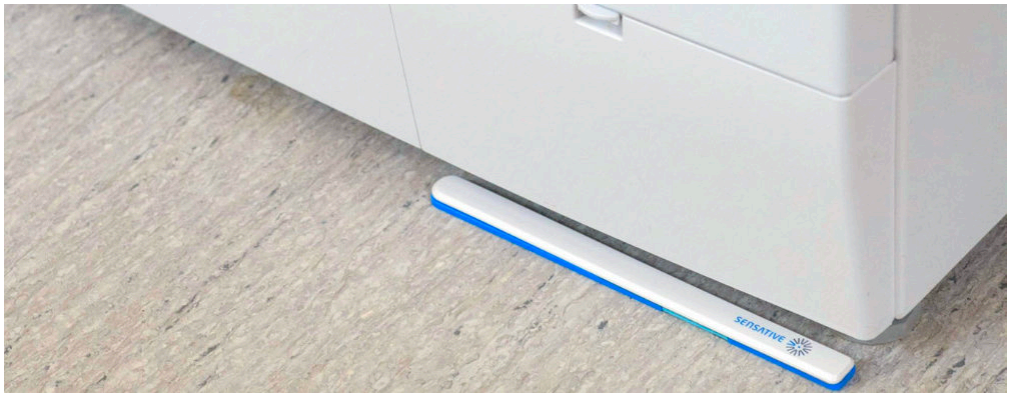
Flood sensors are offered in different designs and various wireless protocols, enabling integration into a smart home system or operation as a single device. Particularly inexpensive products only report water acoustically.

The Sensative Drip

is a brilliant and easy to use water leak sensor. The 3 mm thin sensor carries a battery with an extensive battery life, up to 10 years for Z-wave and 20 years for LoRaWAN. The sensor attaches to a plastic mounting plate, also 3 mm thick, with pads sucking up any water on the surface. Sensing as little as one drop of water, the sensor sends the alarm.

The sensor, including plate, is only just under 6 mm thick, meaning it will easily fit in narrow spaces or under appliances like a fridge or a washing machine for early detection of any water leak.

The Sensative Drip comes in two versions for different standards; Z-Wave (up to 100 m range) or LoRaWAN (up to 10km range).



1.1 m^3 (347 gal) per year

If you have one faucet leaking at a (very typical) rate of ten drips per minute, that one faucet is wasting three liters of water per day. That's 90 liters per month and 347 gallons of water per year.
(source)

0.75 m^3 (200 gal) per day

The typical running toilet wastes 200 gallons of water a day
(source)

$600 per month

cracks in pipes and pinhole-sized holes in pipes typically cost a household between $100-$600 a month
(source)

Flow measurements are an obvious way to detect unwanted water leaks. Unfortunately, it is quite impossible to distinguish escaping (leaking) water from the desired water take. Depending on the sensor system used to detect water flow, the water's minimum necessary flow velocity, which a sensor can still detect, may be too high. For example, waterworks companies use traditional mechanical water meters with a minimum flow threshold as high as 10-20 liters/hour.

Modern metering systems use ultrasonic sensors and can therefore detect significantly smaller water flows. However, the challenge remains of distinguishing escaping water from the legit water takes.

Some suppliers advertise the use of artificial intelligence and machine learning to address this. This sounds very promising but can, unfortunately, lead to undesirable side effects.

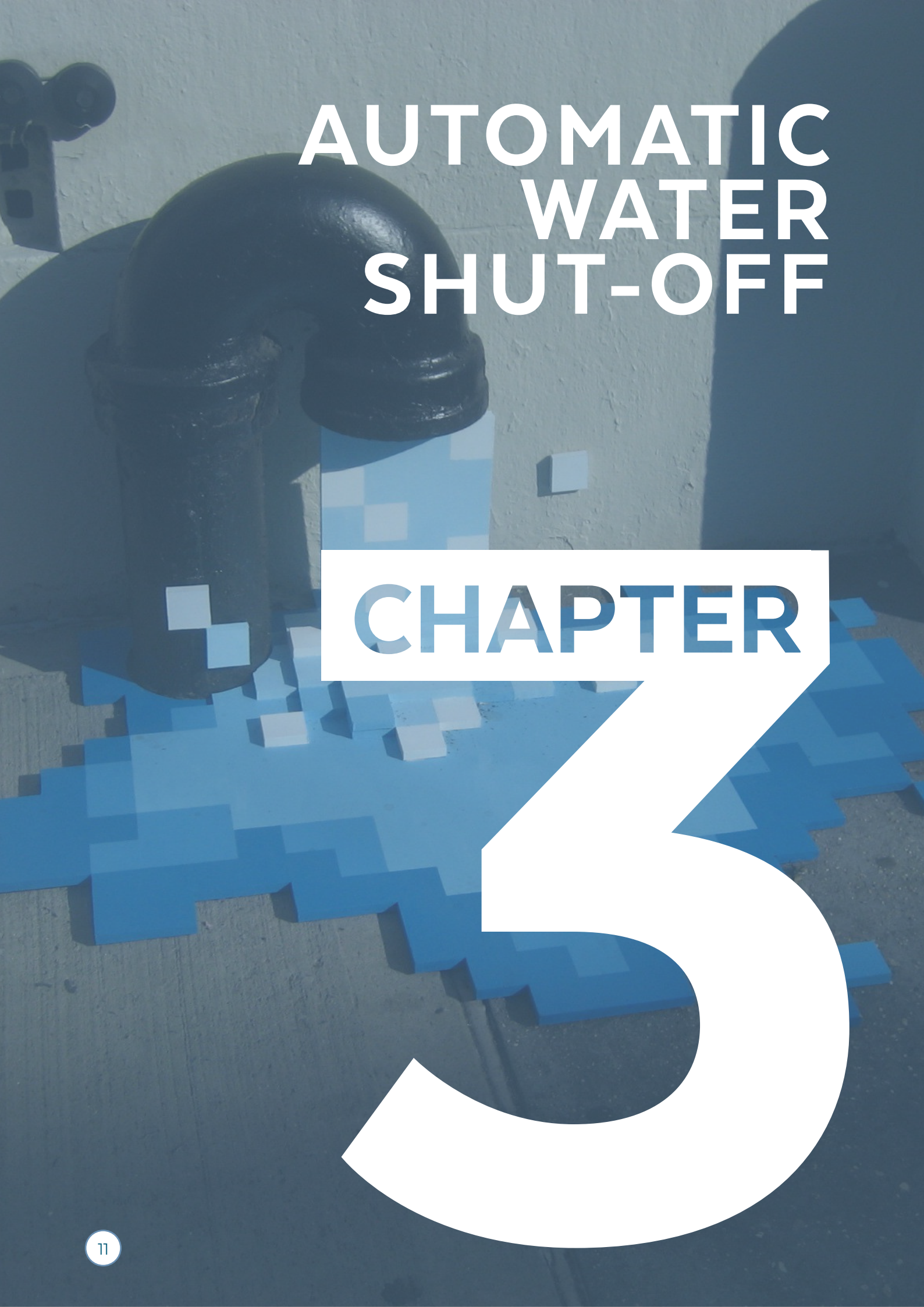
For instance, a homeowner might take a shower between 6:00 and 6:30 in the morning on average working days. After some time, the system learned that a significant amount of water is always used during this period. It can then recognize an equally large water outflow at 8 a.m. or 9 a.m. as escaping water since there is usually no one in the house. The whole thing goes well until the homeowner gets the flu, stays in bed, and then want to warm up in the shower at 8:30.

This shows that if an intelligent system should draw conclusions about legitimate water take and a water leak incident, it needs to be highly sophisticated with many more data sources than just water flow, like motion sensors detecting if anyone is in the shower. It would then be an expensive solution that needed to be tailored to each individual installation, home, family situation, and more.

Microleakage detection

Microleakage detection is a process that is well known to plumbers from heating installations. The piping system is filled with water under certain pressure and then disconnected from the supply line. If the pressure remains, the pipe system is tight. If the pressure drops, water must have leaked somewhere. With this method, even the smallest leaks can be identified, depending on how much time is available to carry out the test. Commercial systems usually perform this test at night for over 15 minutes. Should water be needed unexpectedly during this time, this would be recognized by a sudden drop in pressure due to an open water tap or the toilet flush. The feeder can then be opened again quickly, and the test is repeated later.

Advanced microleakage tests can detect escaping water as low as 4 ml/hour.



AUTOMATIC WATER SHUT-OFF

CHAPTER 3

Once a leak is detected, the continued supply of water must be stopped as soon as possible. If the resident is notified and nearby, he could do this manually by shutting off the main valve. In most cases, however, the water must be switched off automatically.

There are many electrical shut-off options, such as magnetic shut-off valves (solenoids) that can easily be switched off via remote control. Such shut-off valves are rarely pre-installed in a typical domestic water distribution system and therefore have to be retrofitted. For this purpose, the water supply is switched off, the main water pipe is cut at an appropriate point, and the corresponding component is inserted into the pipe. The installation of such a valve is costly and adds additional risk with two new coupling points with different expansion coefficients installed directly in the water pipe and thus represent further potential weak points for water leaks.

Furthermore, solenoids tend to block due to dirt and corrosions, and therefore they are not a reliable option to stop water flow in case of an emergency.

Aqua-Scope retrofit solution

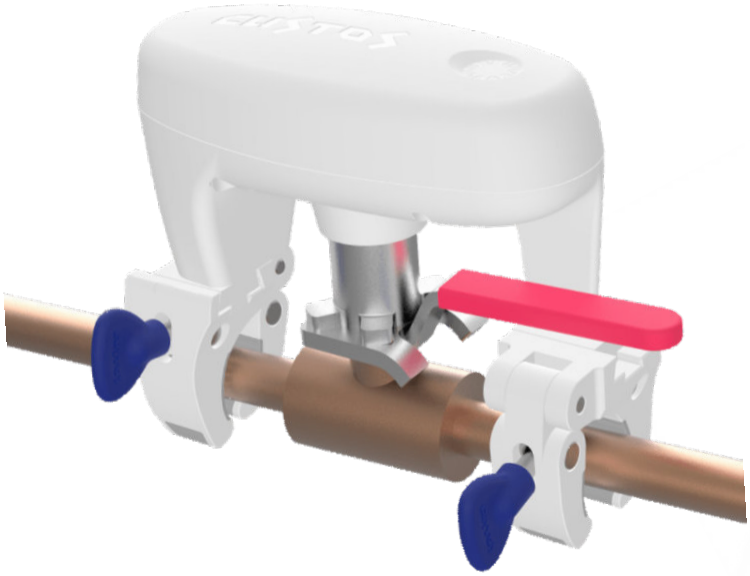
The retrofittable motor servos from Aqua-Scope Technologies offer an alternative. No additional component is introduced into the water distribution, but the already installed shut-off valve is retrofitted by an auxiliary motor.

Aqua-Scope offers two different versions of motor servos for the two most commonly used valve types:

- BVS: For ball valves of diameters between ½ and 1 ½ Inch
- GVS: For Angled Seat Gate valves (KFR Valves) according to DIN 20, DIN 25, or DIN 32

The installation of these retrofit motor servos does not require much time or special knowledge. Any homeowner can do this without prior special training in a matter of minutes.

As soon as the motor servo receives a corresponding control command, they switch off the water in a few seconds. The motor servo will regularly carry out a training run (close plus reopen) to briefly move the valve to ensure that the valve functions perfectly in case of a leak.



Advanced automations and alerts

Intelligent Water Management System

There are several options on the market for Smart Homes and Building Management Systems. Below we highlight some features of Sensative's Yggio, essential capabilities that you should have on the "must-have" on your requirements list.

Sensatives Yggio has a rule engine where you can programmatically respond to and automate actions based on events or a series of events, like if a sensor detects a water leak, close the valve. The strength of Yggio is that the sensors can be from different technologies and suppliers, both wireless and legacy threaded. This means that a modern sensor as Sensative Strips Drip can detect the leak, and an old automatic valve can shut off the water after the rule has been executed in Yggio. An older water meter can send an alarm of excessive water flow, and Yggio can tell the AquaScope to shut off the water. You can mix and choose depending on your situation and what available systems you have installed on the property.

You can also use input from other systems or other events to control the automation. For instance, if you know when the building is supposed to be empty, you can automatically turn off the main valve to the building, protecting it from possible water leaks. This could come from a vacation planning system from HR or by setting a rule when the offices are supposed to be empty for the night. However, suppose someone is in the office outside working hours and wants to use the water. In that case, they could easily push a button (wireless) that sends an instruction to Yggio to open the valve for 10 minutes in the kitchen or 20 minutes in the showers.

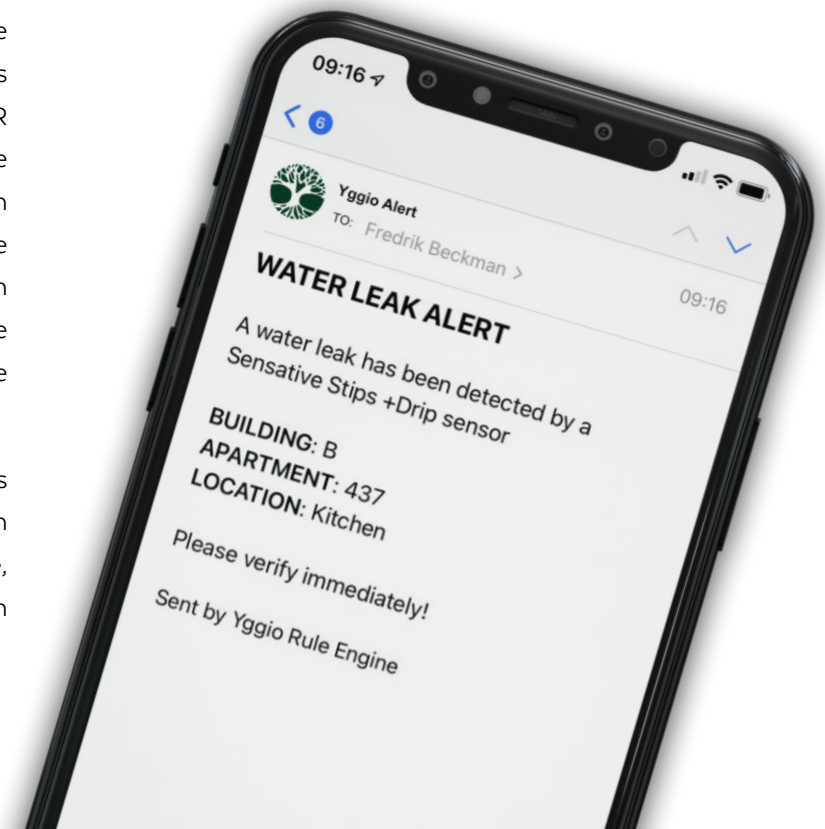
Yggio also has Artificial Intelligence capabilities through a Machine Learning engine that you can train to detect user behavior or anomalies over time, indicating a water leak, clogging, or other distribution system problems. This is cheap insurance against more extensive and more costly incidents and enables the service organization to plan service before it happens.

Artificial intelligence algorithms can help the water utility to become more data-efficient by transforming information into a leaner operation, boosting data-driven decision making through a combination of AI numerical tools and human operational skills.

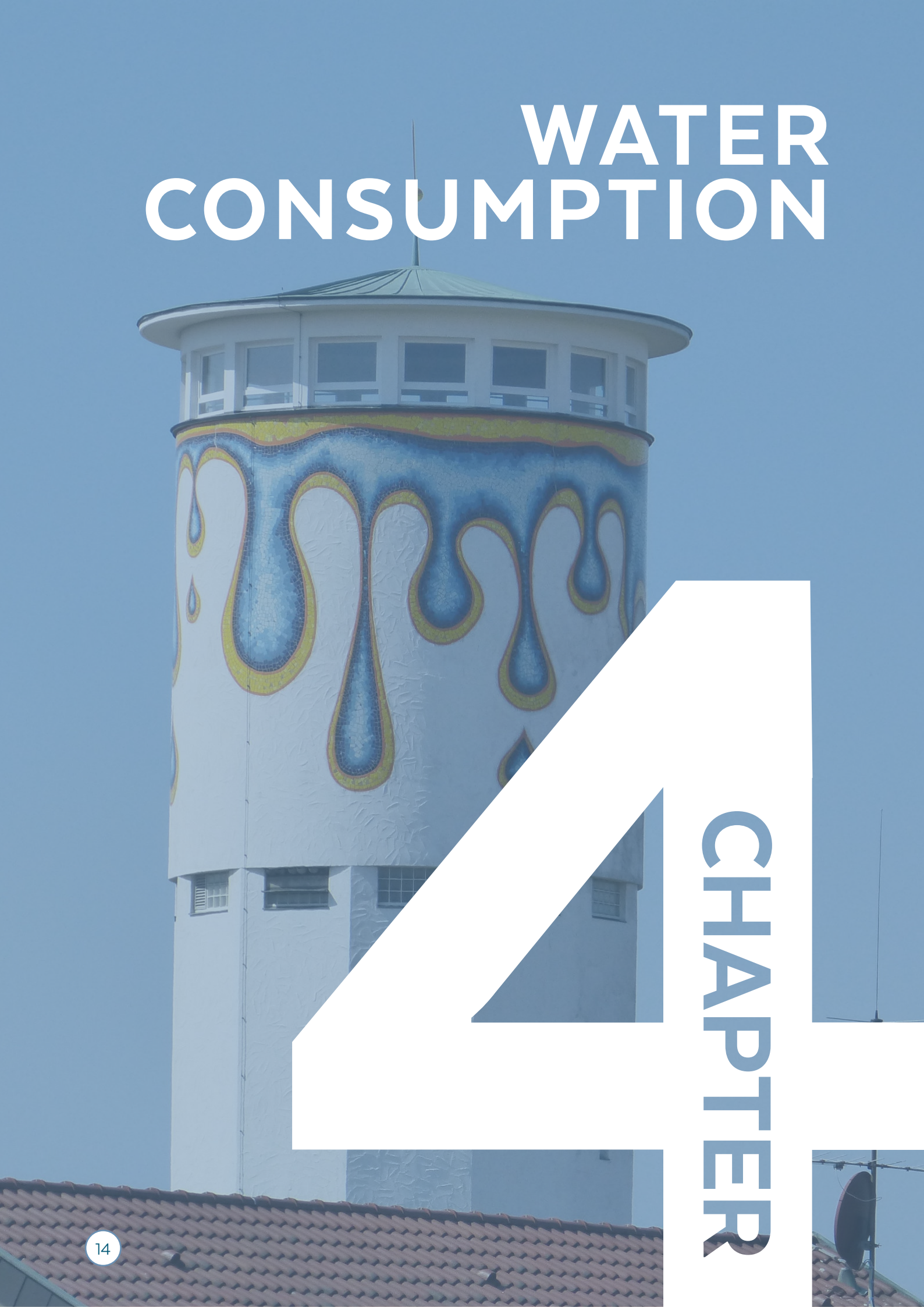
Water shut off alerts

When the water is turned off, the residents must be notified of the situation and, for instance, that the shower or toilet is no longer available. Also, the alarm is only given after a certain amount of water has leaked out. With adequate leakage protection, this amount will be small, but it is never zero, so some action has to be taken to prevent further damages.

As with any alarm system, the user should acknowledge the alarm information's receipt and thereby reset the alarm. This can be done remotely using an app or directly on the leakage protection devices.



WATER CONSUMPTION



CHAPTER 4

"If you cannot measure and record water flow and consumption, you cannot effectively reduce it."

The first step to saving water and saving your business money is working out how much water you are actually using, how much you are wasting, and where you are wasting it.

Non-Revenue Water (NRW)

Non-revenue water is one of the more persistent problems in municipal water systems. It's water pumped or produced but is subsequently lost or otherwise unaccounted for in the system. Eventually, costs associated with theft, evaporation, faulty metering, inadequate or non-existent data collection, and leakage are passed on to the ratepayer.

The following percentages indicate the share of NRW in total water produced:

- Singapore 5% (UFW)
- Denmark 6%
- Netherlands 6%
- Germany 7% (2005)
- Japan 7% (2007)
- In the United States, the loss is estimated at 10 to 30%, with some distributors claiming nearly 50% daily losses.
- England and Wales 19% (2005)
- MWA, Bangkok 25% (2012)
- France 26% (2005)
- Dhaka, Bangladesh 29% (2010)
- Italy 29% (2005)
- Chile 34% (2006)
- Mexico 51% (2003)
- Bauchi state, Nigeria 70%
- Yerevan, Armenia 72% (1999)

https://en.wikipedia.org/wiki/Non-revenue_water

https://www.fluencecorp.com/what-is-non-revenue-water/

Connected meters changes everything

For years, the mechanical meter has been a natural choice. Many technologies, like magnetic, vortex shedding, turbine, positive displacement, Coriolis, venturi, and others - come in direct contact with the flows they are measuring. Many of them have moving parts or electrodes that can become fouled over time. A particulate buildup in the parts of the meters exposed to the flow translates into a need for maintenance, cleaning, and calibration.

Also, mechanical meters usually require manual reading, meaning that the intervals between measurements would be long, maybe months or a year. For efficient logging of water usage and subsequently detailed accurate billing, you need remote reading. A modern smart meter can be connected to a central system for management, billing, and water leak monitoring.

The ultrasonic method is one of the most quickly developing methods in water measurement.

The advantages of ultrasonic metering are many:

- Identifies and reacts to the tiniest changes in any system
- Enables flexible mounting without compromising performance, whether the pipe is horizontal, vertical, or angular
- The smart ultrasonic meter is resistant to dirt and any magnetic field
- Measures extreme low start flow over the entire lifetime compared to mechanical meters
- The meter has no parts that wear out quickly, hence no loss of accuracy over its lifetime and minimal operations cost
- All of that gives the meter a low cost of ownership

The ultrasonic meter also holds remote reading capabilities without the use of any add-on devices. Not only does this contribute to a significant decrease in data collection time. It also improves operational efficiency as you do not have to go onsite to collect the data. You also avoid misreadings and follow-ups and obtain a broader spectrum of data from which you can better serve your customers.

Finally, intelligent alarms in the ultrasonic meter enable efficient detection of leaks, bursts, reverse flows, etc., and thereby lower the amount of Non-Revenue Water in your distribution network and prevent revenue loss.

How Ultrasonic Flow Metering Works

One of the significant benefits of ultrasonic flow meters is that they contain no moving parts and do not need frequent calibration and maintenance. Measurements are made using the transit-time difference method. It exploits the fact that an ultrasonic signal's transmission speed is affected by the fluid's flow velocity. An ultrasonic signal moves slower against the flow direction of the medium and faster with the flow direction. The transit time of the signal sent in the flow direction is shorter than that of the signal sent against the flow. The meter measures the transit time difference and calculates the average flow velocity. Since the ultrasound signals propagate in solids, some meters can be mounted directly onto the pipe's exterior non-invasively.

Sensative has used the ultrasonic water meter QALCOSONIC W1 from Axioma Metering in several customer installations. It is designed for accurate measurement of cold and hot water consumption in households, apartment buildings and small commercial premises.

Aqua-Scope offers an alternative solution based on water sound. The microphone is mounted on a water pipe and 'listens' to the water. It detects all water activities in the whole system thanks to the water's excellent sound conduction. This water monitor fulfills two functions: On the one hand, it determines the water consumption in the house or apartment, and on the other hand, it detects different types of water leaks.

Individual Metering and Debiting

The EU Energy Efficiency Directive (2012/27/EU) emphasizes individual metering and debiting (IMD) of energy and hot water to reduce households' usage.

But this is not only a regulatory and environmental issue. It is common sense to measure water consumption and make it visible for the resident to reduce the cost for both the resident and the building owner. By measuring hot and/or cold water in each apartment to apartment buildings, all the same ability to influence costs as those living in a single-family house. The savings are often around or over 30% of consumption after the installation of measurement systems.

Even if the consumption for one resident is only lowered by a few percentages, the accumulated savings of all residents together make a more significant positive effect. Further, even small leakages, like a dripping tap, can result in excessive water consumption costs. If the wasted water cannot be allocated to a specific apartment and tennant, these leaking costs will only end up for the housing companies. If the resident were aware of the leaking tap's cost, they would be more prone to have it fixed. The cost could also include electricity cost if it is hot water that leaks.

30%

Savings after installing individual measuring systems

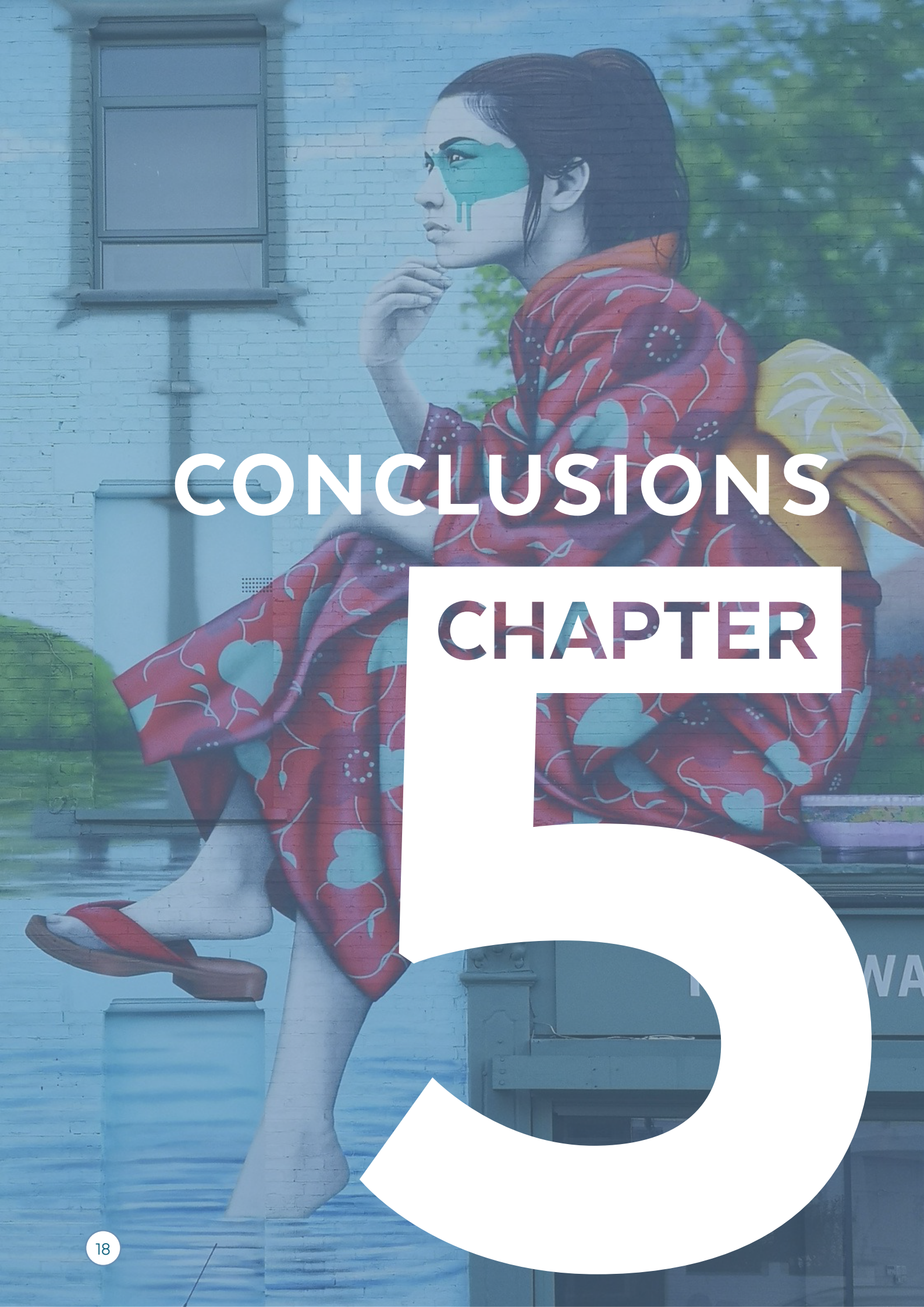
ROI is constantly improving

Water prices and labour costs for meter reading are rising whilst costs for technology and data

Data Driven Decision-Making

Remote digital metering delivers detailed relevant data to planners, water utilities, property owners, managers, and customers. Through real-time analysis of this data, operation managers can make many conclusions to optimize the operations. For example, if a single meter records a water flow for 24h, it is an indication of a leak or open faucet. The manager can then contact the tenant and ask them to investigate. Also, an alarm could automatically be sent if a meter register unusual consumption.

The QALCOSONIC W1 is perfect for remote monitoring of water consumption in individual appartments. When integrated through Yggio, or similar platform, The data is collected and billed automatically.



CONCLUSIONS

CHAPTER 5

Calculating ROI:
Invest in the right solution to save money

Everyone has their own situations, legacy technology, type of operations, and their own lens through which they measure ROI. It also varies between different countries and regions with other cost structures. The easiest way to evaluate the solutions covered by this whitepaper is to investigate some cases and their ROI calculations. From that, you can do your own estimations or contact us here for detailed discussions and a quotation for your specific case.

A US Real Estate Company, calculating ROI for a specific property

- One building, an MDU with 100 apartments
- 15 years old, with HVAC and water systems, now somewhat aging
- Three water-leaks last year, insurance premium increasing as a result
- Due to Covide-19, staff reductions and fewer onsite visits and inspections, so water leaks were detected at a late stage. One water leak evolved into mold.

It is not unusual for a major leak or flood to cost anywhere from US$8,000 to US$65,000 or more to remediate. For instance, mold remediation can easily cost US$5,000 - US$10,000.

Insurance costs and deductibles are rising, for some, significantly. US$50,000 - US$100,000 per event are now not uncommon. In a conservative scenario where a building experiences two events per year costing US$30,000 each, the ROI of a solution from Sensative could range from 1 to 3 years, though for some customers, it will be less than a year.

This estimate does not include costs for business interruptions, temporary relocation of residents, or possible liabilities that could be substantial.

A large Swedish Property Owner calculates their ROI:

- A Sensative +Drip water leak sensor costs, including installation: €100
- 100 apartments cost: €10,000
- The sensors expected lifespan, including battery: 10 years
- Total cost: €10 per apartment per year

A prevented water leak saves them at least €25,000

A single-family home in Germany:

- Risk of a water leak per year and household: 2.5 %
- Average Payout of insurance for leak damage: €2,500 corresponding to 60 % of the total cost
- Calculated cost per year due to leak: 2.5 % of €2,500/60 % = €104.16 per home per year
- The insurance company will likely charge more than the 2.5 % of €2,500 = €62, probably around €100 per year.

(Source German Insurances)

A package with

- shut off valve
- Aqua-Scope water monitor
- 2 +Drip Sensors

With an estimated cost of €500 for the complete installation, the ROI would be less than 5 years. Not including, for instance, the loss of rent, which also is not covered by insurance.

Some final words

Permanent freshwater is a blessing in every home and a great danger at the same time. Leaking water annualy destroys properties for billions of euros or dollars in value.

Leakage protection can effectively reduce the damage caused by escaping water. Such a system has to detect damage, make an appropriate decision, switch off the water if necessary, and inform the resident. It is critical to recognize all possible damage cases and distinguish them from the usual water take. This is only possible through a sensible mix of different sensors and measuring methods.

Despite the considerable damage and losses caused by water leakage, leakage protection systems have rarely been installed. The biggest hurdle is the complicated and expensive installation, which can only be done by certified installers.

The Aqua-Scope System is the world's first comprehensive leak protection installed by even a homeowner without outside help.

Sensative Strips +Drip is an innovative ultra-thin (3mm) and wireless multi-sensor for LoRaWAN with water leak detection, developed for smart IoT applications such as building monitoring and operations. The Drip is excellent at detecting any water leakage and its slim and sturdy design makes it perfect for mounting concealed in small spaces. With a battery life of up to 10 years, you can set it and forget it.

Apart from water leakage, Drip provides temperature, ambient light (LUX) measuring, and magnetic open/close detection (suitable for applications such as windows and doors). This multi-functionality means that the more you realize your own specific needs, the more value our sensors will bring to your company and its operations.

Primary applications for Drip is to alert in case of a water leak, and the temperature sensor can be used to alert if there is a risk of freezing pipes. Integrated to a smart building system and other IoT devices, Drip can automatically turn on/off water flow or sound an alarm to alert the user about the water leak.

More information about
Aqua-Scope products available at
https://www.aqua-scope.com/

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