PreScouter

6 Startup Water Management Technologies

Research Support Service

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Prepared by: **PreScouter**
Kyle Gracey I Project Architect
Jorge Hurtado I Researcher
Xianwei Zhang I Researcher

PRESCOUTER

Intelligence Brief Question

What technologies and/or companies have emerged in the last few years in water management?

The scope should include areas such as water treatment and water conservation. It should focus on startup or other early stage commercialized efforts.

Executive Summary

Despite significant improvements to water conservation and treatment in the past few decades, water management remains a challenge in economically rich and poor countries alike. Worldwide, 80% of wastewater receives no or limited treatment. This contributes to 1.8 billion people relying on faecally contaminated water for drinking. While more than 50% of people now live in urban areas, more than half of all cities do not have sufficient infrastructure to effectively treat all wastewater. Concurrently, over ⅓ of global groundwater sources have entered a “distressed” state, meaning that their consumption exceeds their recharge and they are shrinking. Yet, up to 50% of water is lost in cities due to low quality, aging or inefficient water infrastructure. Even in wealthier countries such as the United States or Italy, 1 out of every 4 to 6 units of water is lost from delivery lines before reaching consumers. In this Intelligence Brief, we examined 6 early stage government programs, companies and nonprofits seeking to address these challenges. The following page summarizes our findings.

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Executive Summary

Water Conservation

- Utilis is a startup using satellite-based microwave radar and image processing to detect leaks
- Startup Infinite Cooling captures the water lost from power plant cooling towers using electrical attraction
- iWesla, funded by the European Union, combines Internet of Things hardware and software to detect and stop leaks throughout an urban water system
- AgriSource Data has field tested its wireless soil sensors, IntelliRoot, at several large farms, saving farmers water and money, or allowing them to increase their crop yields by optimizing irrigation

Water Treatment

- Nonprofit and social enterprise AguaClara uses gravity to drive a community-scale water treatment system for low income areas
- GreenBlu has received U.S. government funding to pilot its Vapor Adsorption Distillation technology for desalination and wastewater treatment

The Technologies Included in the Report

Water Saving Technologies

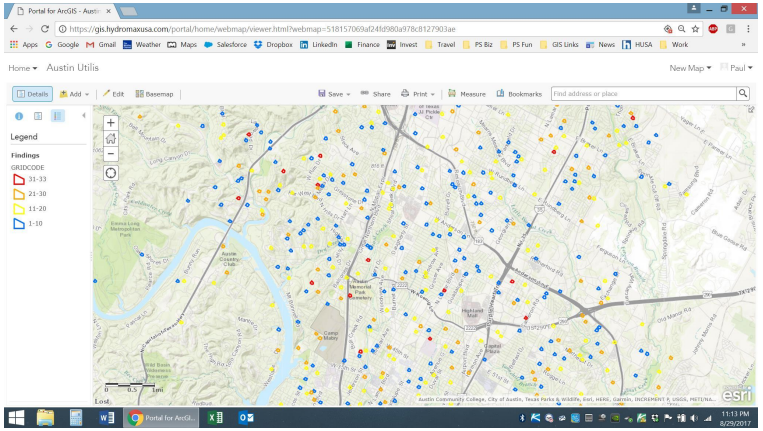
Utilis: Satellite-Based Water Leak Detection

Summary

Utilis is a startup company, headquartered in Israel with a subsidiary in San Diego, CA, USA. It was established in 2013 and has a patented technology which utilizes satellite microwave images to penetrate the ground in the search for water from leaking pipes. Their algorithm brings remote sensing technologies to protect the earth's resources.

Satellite-based water leak detection

Utilis analyzes the satellite images and creates a graphic leakage report containing the location of suspected leaks as geographic information system (GIS) maps. The satellite radar measures the reflected spectral signature emitted by drinking water underground, and works in day or night, cloudy or sunny days. The Utilis service can provide monthly to quarterly plans, enabling quick spotting of water loss as well as long-term analyses.



Utilis: Satellite-Based Water Leak Detection

Technology

The key technology behind the service is the algorithm, which allows accurate and fast analysis of huge satellite images. Because different molecules have different spectral patterns, the algorithm can specifically identify areas with more water close to the ground. Further, because water from different sources have different spectral patterns, the algorithm can differentiate the patterns caused by the leaking pipes compared to normal water-using activities. For example, leaking pipes look different than watered landscaping. The analysis is illustrated below:

Obtain satellite images

Pre-process images

Analyze images

Generate GIS report for leak locations

Utilis: Satellite-Based Water Leak Detection

Advantages

- Satellite image-based technology saves labor and time compared to expensive, ground-based searches
- Covers a larger area (3500 km^2) at once than other technologies, such as aerial photography
- Updates as needed to provide frequent monitoring
- Generate GIS reports marking accurate leak locations (1-100 m) on top of streets and pipes

Limitations

- The satellite data can be expensive and not feasible for small observation areas.
- The technology can suggest leak-affected areas rather than exact leak points. Other detection technologies on ground are still needed.

Utilis: Satellite-Based Water Leak Detection

Commercial Testing / Implementation / Plans

The company is a startup in the growth period. The company has serviced over 100 customers with pilot tests and long-term contracts. The customers with long-term contracts include some of the largest water utilities in the United States, such as San Antonio Water System.

Utilis is also cooperating with partners to extend their service in more areas to provide a more comprehensive water leak detection solution. Partners include Roots Environmental Group Limited (China), Alphalink Solutions (Thailand), SUEZ Advanced Solutions UK Ltd. (UK), 2f Water Venture srl (Italy), HBT - Hanguk Big Technology Co. LTD (South Korea).

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AguaClara: Gravity-Driven Water Treatment

Summary

AguaClara was founded in 2005 with the goal of developing community-scale water treatment technologies. The team was initially within Cornell University's Civil and Environmental Engineering Department. They collaborated with partners to build plants that have provided safe water to over 65k people in Central America and India.

Gravity-driven water treatment

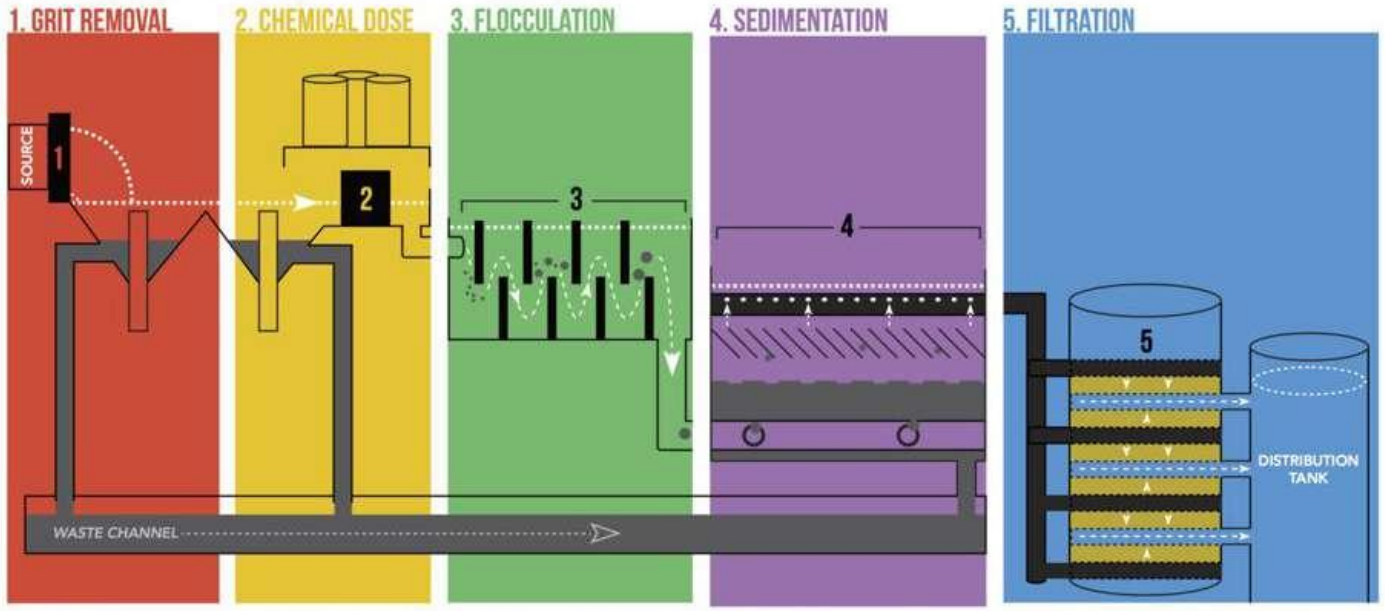
The entire water treatment system is driven only by gravity. The main steps include turbidity removal and disinfection. Each subsystem is developed to run by gravity, and features a simplified and efficient structure to reduce costs from a regular electricity driven system. The parts are modularized and the processes are semi-automatic. People with a primary school degree are able to operate and maintain the system. The technology targets people living in remote villages and/or with low income. The design of the technology is open-sourced, non-patented and non-profitable.

Water entering an AguaClara plant (left) for treatment, compared to water leaving an AguaClara plant (right) after treatment.

AguaClara: Gravity-Driven Water Treatment

Technology

The system is illustrated in the following figure. The process maximizes the usage of the potential energy by the design of the geometry of the flow channel. Filtration is firstly applied to remove large debris. Then a coagulant chemical is added and flocculation is induced by water flowing. Water next goes into a sedimentation tank to settle the flocs (aggregated dirt particles). Finally, the water is filtered again and disinfected by chlorine for drinking. All the processes are innovatively designed to be driven by gravity and validated in the lab to guarantee efficiency.



AguaClara: Gravity-Driven Water Treatment

Advantages

- Operates without the need for electricity, using only gravity
- Constructed by locally accessible parts and materials, including PVC pipes, concrete, mortar, cement
- Simple but functional structure for easy operation and maintenance
- ½ operating expenses (OPEX) and ⅓ capital expenditures (CAPEX) of a conventional mechanized plant of a similar capability
- Scalable to treat water for 300-100k people for as low as $1/month per household
- Proven record in many villages

Limitations

- The water treatment capacity is driven by the natural water hydraulic power, thus is limited to light residential water use and difficult to scale up for industrial use.
- The technology is not able to handle uncommon contamination, such as certain chemicals from industrial wastewater.

AguaClara: Gravity-Driven Water Treatment

Commercial Testing / Implementation / Plans

Since 2005, AguaClara has been building plants in Central America to test and optimize their unique gravity-driven water treatment system. As of today, they have more than 20 plants to supply clean water to more than 65k people. Key principles and designs have also been published in a series of peer-reviewed articles. Overall, this solid track record has proven the practicability and value of their system.

At the initial stage, the main focus of the AguaClara team was the verification of their technology. Now, the team seeks to expand to serve more communities. They have established new social enterprises and new non-profit organizations in different countries and regions. The new companies and organizations plan to hire more full-time team members globally, raise funds from donors and business partners, collaborate with local communities, and develop comprehensive tools (such as mobile apps for operators and maintenance engineers). Currently, they have a plan to globally expand the total water treatment capacity to 500k people in 5 years.

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Infinite Cooling: Power Plant Water Capture

Summary

Infinite Cooling is a startup targeting water capture from evaporative cooling towers of power plants. The company started from an MIT competition in 2016. Their concept has been winning national awards since its establishment. The company is now working towards commercialization, with the start of the first pilot test in Fall 2018.

Electric-field facilitated fog/steam water capture

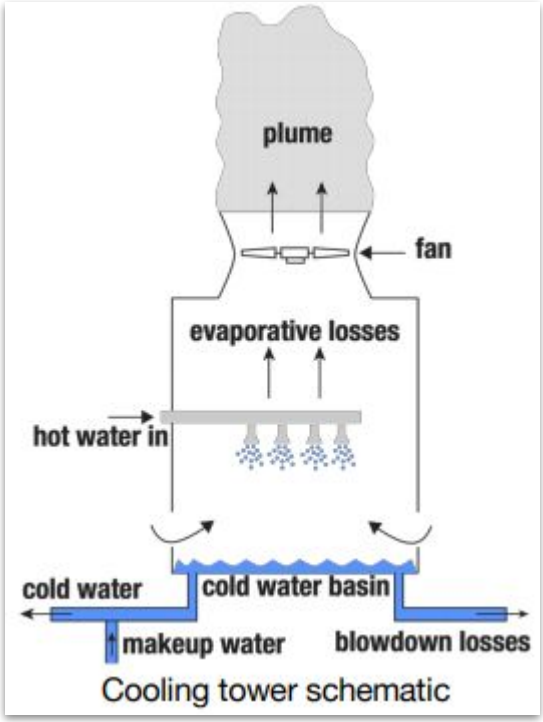
The technology aims to collect water from fog/steam in cooling towers at a high efficiency (up to 100%). It uses various technologies to add charges to the water droplets and then uses a mesh collector with opposite charges to capture the water. The technology uses relatively small energy to achieve a relatively high efficiency.

Full-scale system on 20’ Cooling Tower (MIT 20MW Cogeneration plant)

Infinite Cooling: Power Plant Water Capture

Technology

The company developed a fog/steam harvesting solution consisting of a combination of technologies to capture water. The technology was first designed to provide high-purity water where other means of clean water are not accessible. The technology was later adapted to collect water from the steam of evaporative cooling tower systems. The main goal is to harvest fog droplets 1-40 μm in size, which covers the majority of droplets found in cooling towers. The company claims that the solution can increase the harvesting efficiency from traditionally around 2% to more than 10%, and up to nearly 100%. The energy usage of the solution is claimed to be less than 0.2 per kWh/m^3.



Cooling tower schematic

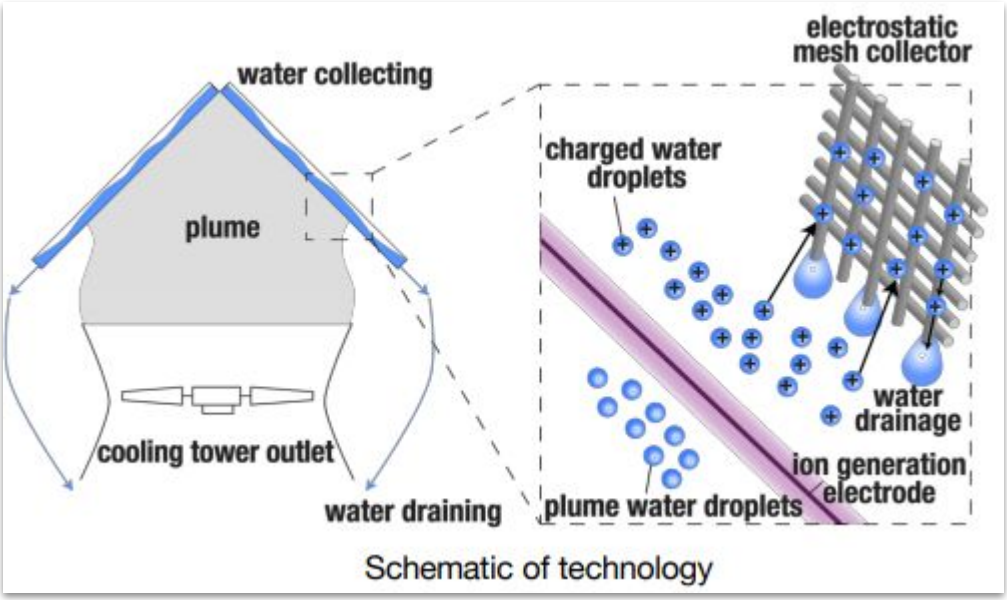
The key components of the technology are 1) charging the droplets and 2) collecting them using a mesh collector with an opposite charge. **Methods to charge the droplets include:** spray charged molecules, electrospray, and ionized gas molecules. The charged species will be adsorbed onto the droplets and thus charge them.

Infinite Cooling: Power Plant Water Capture

Technology

The process also contains technologies to facilitate droplet movement and condensation, including:

1. Electrodes to generate a strong electric field (2-100 kV in 2-50 cm) to guide and accelerate charged droplet movement;
2. Electrode surface with parallel wires or needles around 10 um to promote condensation;
3. Build collectors in the form of meshes and optimize the mesh morphology to increase the water capture efficiency.



Schematic of technology

Infinite Cooling: Power Plant Water Capture

Advantages

- Increase water use efficiency and reduce water usage for cooling
- Reduced environmental impact and better compliance with EPA regulations
- Reduced CAPEX and OPEX compared to other water capture technologies
- Potential to be applied to a wide range of evaporative cooling towers
- Large potential market not limited to the power plants

Limitations

- The technology is still in the development and validation phase and is expected to further develop and optimize in the next few years before being applied to a full-scale cooling tower.

Infinite Cooling: Power Plant Water Capture

Commercial Testing / Implementation / Plans

The company is a startup in the very early stage of seeking commercialization. The technology has been winning startup competitions and gaining funds, including $100K from MIT delta v (a venture accelerator), and nearly $500K from Rice Business Plan Competition.

The company has developed and demonstrated a lab-scale prototype. They are now building their first pilot-scale product at the MIT Central Utility Plant, as of Fall, 2018. The pilot-scale product is currently being tested and optimized. The expectation is to further scale up the product to all power plant scales after the pilot test. Meanwhile, the company has started taking orders from the clients.

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GreenBlu: Vapor Adsorption Distillation with Energy Recycling

Summary

GreenBlu is a US-based water technology company funded in 2016 by Howard Yuh. GreenBlu has recently been awarded US $1.6M by the U.S Department of Energy to commercialize its new thermal distillation technology, the Vapor Adsorption Distillation with Energy Recycling (VADER). With VADER, GreenBlu is capable of providing purified water for human and industry consumption from any water source, with a goal of making zero-carbon, zero-discharge desalination and wastewater treatment affordable.

The Vapor Adsorption Distillation with Energy Recycling (VADER)

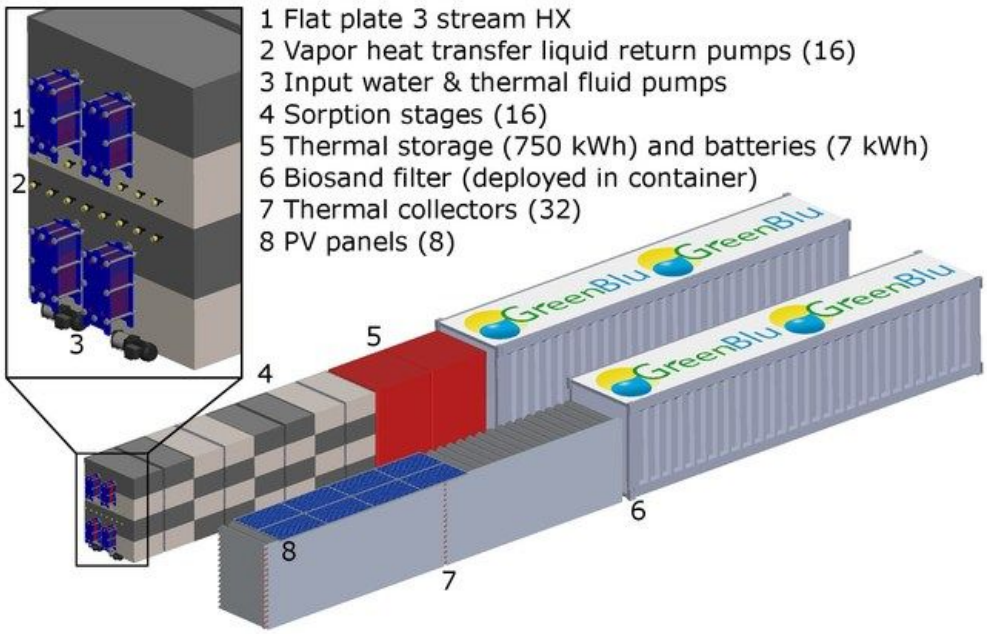
VADER achieves high thermal efficiency with a thermodynamic cycle using an adsorption vapor pump made from a nanomaterial composite adsorbent. Combined with low cost solar thermal collection, a single module of two standard 40ft shipping containers will produce 16000 gallons of water per day. 10 gallons of water can cost as little as $0.01.

GreenBlu's stand-alone module deployed with solar collectors

GreenBlu: Vapor Adsorption Distillation with Energy Recycling

Technology

1. Recycles sensible heat between input stream and product water and exit brine
2. Moves heat pipe fluid to evaporator location
3. Pumps input water into system and circulates heat transfer fluid from solar collectors
4. Adsorption beds with integrated evaporators and condensers
5. Stores heat and a small amount of electricity for nighttime and variable weather operation
6. Container for transporting solar collection can be deployed as a gravity sand filter
7. Evacuated tube collectors with 1D-tracking low concentration reflectors
8. Generates the small amount of electricity required for pumps



Envisioned modular, grid-independent adsorption distiller

GreenBlu: Vapor Adsorption Distillation with Energy Recycling

Advantages

- A cost-effective technology reflected by its low maintenance requirement and low cost of water per cubic meter.
- VADER is powered by solar energy.
- It does not require the use of membranes. Permanent adsorbent contacts only pure water vapor and does not need replacement. This also allows the system to produce safe drinking water from any source.
- VADER can solidify even high total dissolved solids wastewater, including reverse osmosis brine.
- Purified water with VADER technology can be used for drinking and industrial use.

Limitations

- VADER is still in the process of integrating all the components into a commercial unit.
- The company acknowledges that research needs to address how a commercial unit can efficiently self-sustain if it is to operate in remote locations.

GreenBlu: Vapor Adsorption Distillation with Energy Recycling

Commercial Testing / Implementation / Plans

- The technology is quite simple, novel and viable and has captured the attention of academia researchers, private and non-private sectors.
- As of October 2018, GreenBlu has begun using its US $1.6M award from the U.S. Department of Energy's Solar Energy Technologies Office (SETO) to further develop its VADER technology and produce the first prototype of the commercial product by 2020.
- Marketing of the product is expected to start in October 2021.

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iWesla: Demand-Side Cyber-Physical System

Summary

iWesla or *improving Water Efficiency and Safety in Living Areas* represents a tested concept funded by the European Union's Horizon 2020 research and innovation programme. The project started in 2016 to develop and implement a demand-side cyber-physical system, or CPS, to optimize water consumption efficiency and safety in living areas.

Demand-side cyber-physical system (CPS)

iWesla uses an innovative "demand-side cyber-physical system" (smart meters, sensors, actuators, data analysis and processing) to identify patterns in water use per household. Data collected by iWesla using IoT platforms allows to understand how and where water is consumed across metropolitan areas.

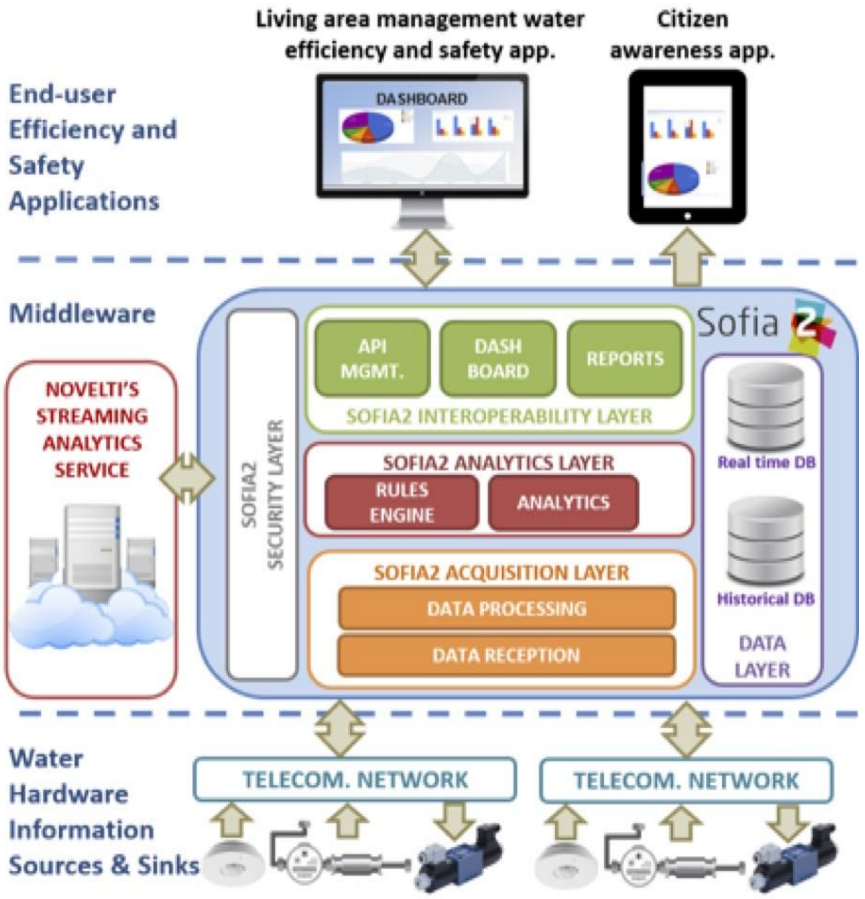
iWesla Flow Meter Mote at Rivas Facilities. Source: iWesla

iWesla: Demand-Side Cyber-Physical System

Technology

A physical water structure that needs to be controlled and monitored is initially supplied with **smart water meters** as information sources, and **electrovalve actuators** to obtain control over the water network. Water hardware is then connected to **Sofia2 (IoT platform)** that allows the operability of multiple systems and devices, offering a semantic platform to send orders to the actuators or any other smart applications within the system.

An artificial intelligence system monitors the data stream and detects patterns and anomalies in daily water use. The A-CING Consumption Awareness Application (Citizen Awareness App) provides up-to-date information and indicators of water usage.



iWesla: Demand-Side Cyber-Physical System

Advantages

- iWelsa has shown the ability to monitor all aspects of water infrastructure where the project has been tested, offering the potential to monitor infrastructure at larger scales (e.g. municipalities, cities).
- Increased water efficiency use: Due to the ability of the CPS to detect patterns of water consumption, the iWelsa project tested at the university campus of the Technical University of Madrid, a primary school, and a sports centre in Madrid, Spain saved up to 40% of water consumption on average across all 3 sites.
- Using a smartphone application, iWesla warns users of water overused or potential leaks with alarms, and gives the possibility to close water flow by accessing the electric valve remotely.

iWesla: Demand-Side Cyber-Physical System

Limitations

- Although the project has claimed success in tests, this is a government project and it is not clear whether further testing and development is planned, nor is there a clear path yet to commercialization.
- What remains unclear is how iWesla addresses disaggregation of water consumption at home. The program currently can tell that there is an overuse of water in a unit, but cannot tell which fixture could likely be at fault. Thus, individual patterns of water use detected by iWesla relates to a household rather than to individuals within.
- The number of devices and monitoring systems required to manage a large area (e.g. a city) creates significant complexity and expense.

iWesla: Demand-Side Cyber-Physical System

Commercial Testing / Implementation / Plans

The iWesla concept was tested in 2016-2017 in three different places within the city of Madrid, Spain: Universidad Politécnica de Madrid, a primary school and a sports centre provided by the Municipality of Rivas Vaciamadrid and Amadora's Town Hall. The project reduced water consumption by 40%.

The success of iWesla has driven the development of two new projects by the CPS Laboratory in Spain, based on the Minsait Internet of Things and Big Data platform, the results of which will be available soon. These project aim to facilitate experimentation with products and services to accelerate knowledge transfer to industry in Europe. A German company, Fortiss, is the lead consortium coordinator that includes the collaboration of nine European companies from Germany, France, Sweden, the UK and Spain.

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AgriSource Data: IntelliRoot Soil Sensor

Summary

Founded in 2015 and with headquarters in Atlanta, GA, AgriSource Data uses a "multi-layer intelligence approach" characterized by its intelligent root field sensor. AgriSource Data relies on machine learning technology for precision agriculture and smart irrigation management. The company claims to have saved more than 7 million liters of water and increased average crop yield by 10% using its AgriSource Data "multi-Layer intelligence approach." The technology has been already deployed to 7 countries in 2018.

IntelliRoot Soil Sensor

A highly accurate sensor capable of forming a wireless network that indicates the volumetric water content and temperature of farm's soils at multiple depths. The data collected every two hours is then transmitted to a central portable device. The information allows the farmer to manage water optimally.

The IntelliRoot Soil Sensor

AgriSource Data: IntelliRoot Soil Sensor

Technology

The IntelliRoot soil sensor monitors moisture and temperature at multiple depths. The IntelliRoot can communicate with other sensors placed in the farming area from up to four miles away, offering higher data transfer rates that provide real time alerts and immediate self diagnostics. A single data gateway can monitor and collect information from **250 sensor locations within a four mile radius**.

IntelliRoot helps irrigation managers to see the availability of water at the root zone. The system offers irrigation managers a quick analysis of the moisture level on a data portal, so they can determine if the crops are in need of water. Sensors are calibrated depending on farmers' need in terms of soil and crop types.

Intelliroot can also be combined with additional sources of data collection that are fed with satellite and drone imagery. This not only allows farmers to optimize irrigation scheduling for water conservation, but also accurately predict harvest yield and schedules. The multi-source field data is stored in a secure cloud-based system. Using advanced artificial intelligence and machine learning, AgriSource can produce a comprehensive assessment of best and worst water management practices across an entire geographic area.

AgriSource Data: IntelliRoot Soil Sensor

Advantages

- Affordable, easy to install and calibrate.
- Fed by a battery pack that lasts up to two years.
- Units are wireless and therefore capable of forming a compact network with additional units within a large radius (~ four miles).
- Communicates using three different protocols optimized for different situations: Random Phase Multiple Access for machine-to-machine, LoRa Low Power Wide Area Network standard for long range and remote areas, or cellular when wireless carriers are within range.
- Company claims it can improve crop yields between 30-50%.
- A versatile sensor that can be customized depending on soil and crop types with a well-developed platform.

AgriSource Data: IntelliRoot Soil Sensor

Limitations

- It remains unexplained/unclear how IntelliRoot addresses common problems that have not been resolved by other currently used soil sensors: corrosion of electrical contacts, dissolution of matrix materials, erratic readings due to air gaps between sensors and soil.
- It is also unclear if the high levels of water saving relates to just the sensors themselves, or to a combination of technologies that the company has named a "Multilayer Intelligence Approach (MIA)." MIA combines multi-source data across major agricultural regions, data collectors that include a variety of sensors (not just the soil sensor), and a data analysis platform.

Commercial Testing / Implementation / Plans

The sensor is currently being commercialized in the United States and several other countries. Several case studies demonstrate the potential for IntelliRoot to increase yield and improve water management. For instance, in the United States, potato and corn farmers obtained between 30-50% higher yields during dry years by maximizing scarce water usage. IntelliRoot also saved farmers up to 30% on their water spending during wet years by optimizing irrigation events.

AgriSource Data: IntelliRoot Soil Sensor

Commercial Testing / Implementation / Plans

The adoption of a multi-unit IntelliRoot system on a 100 Ha vineyard in Washington State helped to induce water stress at the appropriate time, which increased brix count and elevated varietal value as much as 30%. The level of brix in grapes determine the levels of sugars that a crop must have during harvest to express the proper degree of alcohol in wine. Likewise, sugar cane farmers that adopted IntelliRoot soil sensors increased brix content by as much as 7%, which resulted in a direct increase of 7% sellable tonnage.

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Next Steps

Topic	Question	Report
Market Analysis	What are the largest segments within the water management market, and how mature are they?	Intelligence Brief 2
Patent Landscape	Which companies have been most active in the past 3 years in filing patents for water management technologies? What are the most active patent classes and their geographic distribution?	Intelligence Brief 3
Centers of Excellence	Which companies and academic research groups are leaders in developing water management technologies?	Intelligence Brief 4

About the Authors

Kyle Gracey

PreScouter

Professional Summary: Kyle is a Senior Project Architect and the Natural Resources Industry Lead, overseeing PreScouter's projects with clients in water, utilities, renewable energy, mining, metals and fossil fuels. He has managed over 75 projects for PreScouter. A recognized expert in sustainability technologies and policies, Kyle previously worked for private and nonprofit natural resources consulting firms, sustainability think tanks, the United States Departments of Transportation and the Treasury, the White House, Carnegie Mellon University, and the United Nations. Kyle's research, publications and education are in the fields of environmental engineering, geophysical sciences, public policy, economics and biochemistry/biophysics.

About the Authors

Jorge Hurtado

Syracuse University

Professional Summary: As a scientist, Jorge aims to study sustainability and development issues that can generate positive changes in the lives of local communities. Jorge finished his Master's degree in Tropical Conservation and Development from the University of Florida and completed his PhD in Biology at Syracuse University. Jorge is based in Canada, where he was until recently, working for Environment and Climate Change Canada. Jorge has lately become more involved in communicating science to specialize and general audiences, and still diverges most of his efforts to work as an environmental consultant and to teach kids the need to keep in touch with nature.

About the Authors

Xianwei Zhang

Colorado School of Mines

Professional Summary: Xianwei is a research fellow at Colorado School of Mines. He collaborates with industrial and academic partners to study the fundamentals and applications of clathrate hydrates. He obtained his Ph.D. degree in chemical engineering from Colorado School of Mines for hydrate risk evaluation in oil and gas production systems. Out of the lab, he is interested in analyzing new technologies and their impacts on business.

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