The Future of Water Management:

A Menu for Policymakers in the Digital Industrial Era

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Table of Contents

Executive Summary

Governments in many parts of the world are facing acute water and wastewater infrastructure challenges, often resulting in pipe leaks, water main breaks, sewage overflows, and other hazards that not only waste valuable water but also could affect public health and the environment. In response to these challenges, many water and wastewater utilities have recently adopted digital solutions via the Industrial Internet. Digital solutions are already proving their potential by helping to transform the way utilities manage treatment, distribution, and customer interaction.

While many governments are looking for ways to promote more rapid adoption of digital water solutions, they often have difficulty finding information on the policy options from which they might choose. The purpose of this white paper is to provide such a menu of policy options, drawing on examples from around the world. While this is only a representative sample and does not provide an exhaustive list of programs and policies, the major types of policies being used promote adoption digital water solutions include the following:

Education and Outreach

- Recognition awards and certification programs
- Strategic communications and educational initiatives

Removing Barriers

- Refrain from mandating specific water technologies and instead mandate desired results
- Employ reporting mechanisms that can take advantage of new digital water technologies
- Implement government financing models which can reduce costs and catalyze local infrastructure projects to fix, expand, and digitize water systems
- Use Public-Private Partnerships (PPPs) to lower costs, engage in risk-sharing, and introduce private sector expertise and innovation to water utilities
- Incorporate digital water management into Intelligent City initiatives

Incentives

- Provide financial incentives in the form of subsidies, grants and tax breaks
- Offer financing through public bank and infrastructure fund low interest rate loans and investment

Regulations and Standards

- Adopt performance-based standards developed in a collaborative environment including industry stakeholders
- Recognize that Industrial Internet data are different from consumer data, and adopt appropriate cybersecurity and data policies

This policy review provides a valuable starting point for governments to evaluate the appropriate mix of policies that will best fit their needs. In some cases, information will be enough to spur action, whereas in others, financial incentives or regulatory requirements will be more effective.

Digital water software platforms are available to be deployed globally across water treatment and distribution systems as well as the consumer level.

For further information on how this policy menu might be applied, please visit **www.gewater.com**.

Introduction

Governments around the world are facing acute water and wastewater infrastructure challenges, often resulting in pipe leaks, sewage overflows and other hazards that not only waste valuable water but could also affect public health and the environment. For developing countries, lost or non-revenue water can account for 50 percent of total water withdrawn from the environment[1]. The World Bank estimates that the total cost to water utilities caused by non-revenue water worldwide can be conservatively estimated at $141 billion per year and represents enough water to service nearly 200 million people[2]. In the US, infrastructure issues including water main breaks, sanitary sewage overflows, storm water overflows, and water pipe degradation will result in an estimated $59 billion increase in costs to households due to higher water rates, and a $147 billion cost increase to utilities by 2020[3]. Central to the problem is that water utilities are oftentimes have trouble detecting an issue, such as a pipe leak, until it becomes a major, and highly visible, problem. Without a full set of data and insight into network infrastructure conditions, operators are trapped in a reactive cycle.

According to research commissioned by a leading utility infrastructure company, digital water networks can save utilities up to $12.5 billion a year[4]. Digital water solutions have the potential to connect water plant operations with distribution networks to optimize the holistic treatment and delivery lifecycle for drinking and waste waters. Software-as-a-Service (SaaS) can produce operational efficiencies that improve water quality and availability for municipalities and consumers worldwide. Using data and analytics, digital industrial companies, such as GE, can work with utilities and consumers globally to solve the challenges of water distribution, storm water and wastewater collection. Municipalities and water utilities worldwide can use a seamless software solution set built on industrial internet platforms to put their data to work, addressing aging infrastructure, manpower constraints, and water conservation.

The purpose of this white paper is to help governments at various levels think through their options for facilitating adoption of digital water solutions. The paper is built around a menu of policies that are being used in different locations, including efforts to:

- Use strategic communications and educational outreach to promote digital water management and technologies
- Remove barriers to the adoption of digital water solutions
- Direct financial incentives to facilitate changes in water utility behavior and public attitudes
- Promote open water sector standards as well as data democratization and transparency

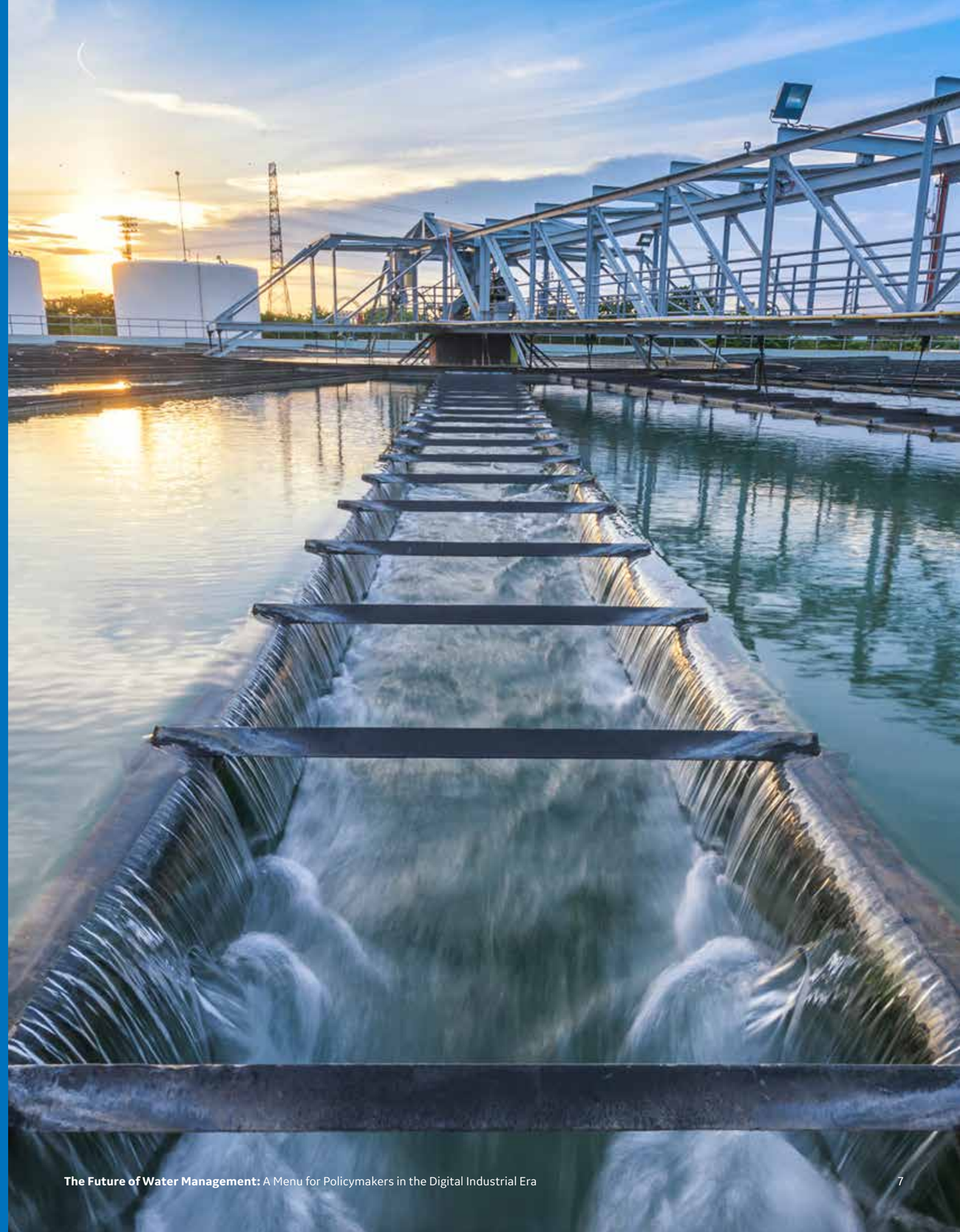
This menu offers a spectrum of policy tools ranging from less intensive mechanisms, such as making information available, to more proactive regulatory approaches that remove barriers to digital water adoption. Examples of how these policies are applied in international and domestic locales are included below.

[1] The World Bank Group, "The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries," Water Supply and Sanitation Sector Board Discussion Paper Series, Paper No. 8, December 2006, http://siteresources.worldbank.org/INTWSS/Resources/WSS8fin4.pdf?_sm_au_=iVH73HNQ4ZHPm47l

[2] The World Bank Group, ibid.

[3] American Society of Civil Engineers, Bridging the Water Gap: Investing in America's Water Infrastructure, 2011, http://www.asce.org/water_and_wastewater_report/.

[4] Sensus, "Water 20/20: Bringing Smart Water Networks into Focus," News Release, December 2012, http://www.smartwaternetworks.com/



Education and Outreach

Education and outreach is generally perceived as critical to advancing digital water approaches. As a result, most countries, states/provinces and municipalities where utilities leverage digital water solutions have active public education programs. These programs are often supplemented by broader governmental campaigns.

Governments raise awareness through many common techniques including:

Recognition awards and certification programs support digital water adoption efforts by:

- Presenting awards to entities that have voluntarily made significant contributions to digital water technology
- Officially recognizing digital water adoption in government publications and websites, particularly those efforts that are innovative or act as role models
- Developing government certification programs for digital water management and technologies

For example:

- **Global Water Intelligence (GWI)** provides several annual recognition awards to companies that adopt digital water solutions. GWI's "Water Performance Initiative of the Year" award recognizes the most significant commitment to improving long-term performance of water services to the public. Additionally, the "Water Technology Idol" award is presented to the early-stage company whose technology could change the future of the water market[5].
- The **Water Industry Alliance** of South Australia (WIA), a cluster of 150 water-related organizations focused on sharing South Australia's water expertise with the world and growing the region's water industry, hosts an annual Smart Water Awards to recognize excellence in this field. WIA awards recipients across seven categories, one of which includes smart water solutions to water treatment and reuse[6].
- The **Certified Water Efficiency Professional (CWEP)** program presented by the Association of Energy Engineers is designed to help educate and qualify individuals in the water/energy management field on best-practices for improving water efficiency. By obtaining the CWEP certification, candidates will gain industry and peer recognition by demonstrating their understanding of technical and operational water management principles. Certification training includes tutorials on the ways in which digital water networks optimize water efficiency[7].

Strategic communications and educational initiatives are the most common mechanisms used by governments to influence the adoption of digital water management and technology. Governments' communications and outreach efforts target several audiences including utilities, communities, information and communications technologies (ICT)professionals, academia, businesses, and others. These efforts are communicated across both conventional and social media and raise awareness of digital water solutions by:

- Promoting publicly available water data and mapping tools that demonstrate the impact and feasibility of integrating water data and monitoring water quantity and quality
- Organizing digital water conferences to discuss the latest technologies, methodologies, practices and research
- Educating utilities and the public on the financial benefits of digital tools for water management
- Hosting crowdsourcing and open innovation challenges

For example:

- The **US Government's Open Water Data Initiative (OWDI)**, which makes water use, water quantity, and water quality data publicly available will continue to work with stakeholders and decision makers to make available the science, data, and tools needed by states, local communities, tribes, and businesses as they prepare for drought and water reliability challenges[8].

[5] http://www.globalwaterawards.com/2015#WaterTechIdol)

[6] https://www.waterindustry.com.au/Public/About_Us/Public/AboutUs/About_Us.aspx?hkey=a75a93b6-d5f7-43aa-bcd9-16d3f1b75f2b

[7] http://www.aeecenter.org/i4a/pages/index.cfm?pageID=4454

[8] https://acwi.gov/spatial/owdi/

- The **British Columbia Government of Canada's Living Water Smart Program** offers publicly-accessible water data and mapping tools to find regional information about water, climate, and the environment. Residents may also find information about water use and rights in different regions. The program also offers federal and provincial monitoring data about water quantity and quality[9].
- The South Korean Government's Ministry of Land, Infrastructure, and Transportation organized **SMART Water Grid International Conference** to gather professionals to present and discuss the latest technologies, methodologies, practices and research advances in the development and implementation of Smart Water Grid and its water management plans[10].
- The **Australian Government** conducts surveys of water utilities that use smart water meters, gauging how they're used, and to better understanding the barriers to digital water adoption and the associated financial benefits[11].
- The **Queensland State Government of Australia** engaged in a robust public relations campaign to bolster support for digital water solutions' capacity to reduce water usage and utility bills, leading to a 12-month trial for digital water meters for Queensland's Sunshine Coast. Residents can check their daily water usage, analyze consumption through a self-service dashboard, and receive electronic alerts of leaks from state-owned utility, Unitywater[12].
- To merge the roles of innovator and end user, the District of Columbia Water and Sewer Authority, DC Water, launched the **DC Water Open Innovation Challenge** which encourages employees to identify emerging technologies and upcoming regulatory changes, undertake scientific research, and ultimately make recommendations for new technologies or practices to be implemented[13].

[9] http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools

[10] http://www.swgic.org/

[11] http://ac.els-cdn.com/S0957178714000976/1-s2.0-S0957178714000976-main.pdf?_tid=3a7c2a20-3e1f-11e6-9947-00000aacb362&acdnat=1467221632_5e1765f50968b7b44f176448d15f620d

[12] http://www.itnews.com.au/news/sunshine-coast-to-get-digital-water-meters-430616

[13] http://www.wateronline.com/doc/dc-water-develops-its-own-future-with-open-innovation-0001?vm_tId=1936679&user=a78fb9b9-5796-4050-87d1 e6508dc7fa1e&utm_source=et_10759433&utm_medium=email&utm_campaign=WOL_07-07-2016&utm_term=a78fb9b9-5796-4050-87d1-e6508dc7fa1e&utm_content=DC+Water+Develops+Its+Own+Future+With+Open+Innovation

Removing Barriers

Barriers to digital water management and technology adoption come in several forms, including regulatory, financial, subject matter expertise, and lack of collaboration and information sharing between organizations.

One of the biggest barriers to digital water adoption is outdated water sector regulations and mandates. Both the Clean Water Act and the Safe Water Drinking Act require high levels of data validation and verification, which can be difficult to achieve with disparate systems that are not connected to one another. Regulations which usually require periodic reports though **new reporting mechanisms can take advantage of new technologies**, such as electronic reporting of continuous data.

For example:

- The EPA-mandated **National Pollutant Discharge Elimination System (NPDES) Electronic Reporting Rule** signed in September 2015 replaces most paper-based Clean Water Act (CWA) NPDES permitting and compliance monitoring reporting requirements with electronic reporting. The publication of this rule was the latest step in an extensive multi-year outreach effort with EPA's state, tribal and territorial partners[14].

Testimonials from water industry and ICT processionals indicate that the process of enacting policy often does not keep pace with the rate of technological change. **Therefore, governments may consider whether it makes sense to mandate specific technologies over desired results. Mandated results could include water efficiency, conservation, leak reduction, quality, and storm and sewer efficiency**.

For example:

- In 2015, **California state regulators issued a state-wide water conservation order** that required at least 25 percent savings across the state. In May 2016, the state provided district water utilities the flexibility to propose their own standards. This enabled the them to adopt standards tailored to their desired results, and has allowed the utilities to adopt digital water solutions ideally suited to their respective water conservation goals[15].

Financial and subject matter expertise deficits are another critical barrier to digital water initiatives. State, provincial and municipal governments' budgetary constraints means that innovative financing models may be necessary. Moreover, local water management utilities often lack the data scientists, managers, or the resources to hire professionals in digital water management and technology. Potential solutions to these barriers include:

- Implementation of federal government financing models which can reduce costs and catalyze local infrastructure projects to fix, expand, and digitize water systems (as further discussed in the Incentives section of this report)

- Use of Public-Private Partnerships (PPPs) to lower costs, engage in risk-sharing, and introduce private sector expertise and innovation to water utilities

For example:

- In 2011, the **Sonoma County Water Authority (SCWA)** began using smart technology to monitor water pressure at critical distribution points in real-time and adjust pressure as needed. SCWA can collect and analyze data on water usage, current weather and other environmental considerations to efficiently manage its water distribution system. This approach has proven to be successful for both SCWA and the public. Leaks in the water district have decreased by 30 percent since the system went online and SCWA estimates the program saves them upwards of $100,000 annually[16].

- In 2008, the Mayor of Chicago created the Department of Innovation and Technology to oversee cross-departmental projects such as the, **"Array of Things" (AOT) Commercial Partnerships Initiative**. Under this initiative, a network of sewer sensors was deployed to map the capacity and use of underground water systems. This allows the city to identify where "bottlenecks" in the pipes are occurring as well as determine the efficacy of its green infrastructure and other installations that are supposed to capture storm-water before it reaches the drain.

[14] https://www.epa.gov/compliance/final-national-pollutant-discharge-elimination-system-npdes-electronic-reporting-rule

[15] https://www.theguardian.com/us-news/2016/may/18/california-drought-conservation-order-lifted-jerry-brown

[16] http://www.naco.org/sites/default/files/documents/2015_Smart-Infrastructure_06.18.pdf

- In September 2015, the US National Institute of Standards and Technology (NIST) and several commercial partners launched the **NIST Global Cities Team Challenge (GCTC)** to bring together communities with challenges and innovators with the technology to overcome them. As part of the GCTC, the cities of Las Vegas, Los Angeles and Atlanta have teamed with AT&T and IBM to develop a digital network to identify leaks in city water infrastructure pipes – a problem that causes up to 40 percent of unexplained water losses in cities worldwide.

Lack of collaboration and information sharing within and between utilities and the infrastructure sectors represents another significant barrier to digital water adoption. Siloed communications and initiatives between utilities and sectors have stymied digital water management and technology. National and city-wide planning efforts to integrate water, energy, communications, and transportation systems are complex and have a longer time horizon that can make them difficult for decision makers. However, **digital water management is highly incorporable into Smart Cities**, as several domestic and international case studies have proven.

For example:

- In **South Korea's "Songdo" Smart City**, a new city built on the peninsula off the coast of Seoul, the government has engaged in city-wide planning efforts to integrate water, energy, communications, and transportation systems. The wireless sensor networks used in Songdo are designed specifically to create smart cities. City authorities have equipped the water distribution system with sensors for leak detection, pipeline management and storm water management as well as water quality and asset performance management in water treatment[17].

- In conjunction with the **Israeli Smart City initiative in Jerusalem**, the city's water utility, the **Hagihon company**, deployed over 2,000 remote sensors in its 1,200 km of pipes. Along with quality metrics that affect the integrity of the pipes, the sensors also monitor pressure through the network. In addition to identifying peak demands in real-time, and adjusting supply treatment accordingly, it also allows Hagihon to detect leaks in the piping system. The connected sensors on the distribution system quickly notice inaccuracies and loss of flow, allowing for timely inspection and repair[18].

- Toronto continues to be a leader across several fronts with respect to Canada's smart cities. In 2013, **Waterfront Toronto** launched newblueedge.ca to allow residents to have real-time web and mobile access to transit information and traffic congestion reports, public transit information, local weather and news reports as well as energy- and water-consumption data[19].

- To combine several lines of big data across city departments, the city of **Chicago launched the "Array of Things" initiative** in 2015. AoT will provide real-time, location-based data about the city's environment, infrastructure, and activity to researchers and the public. This initiative has the potential to allow researchers, policymakers, developers and residents to work together and take specific actions that will make Chicago and other cities healthier, more efficient and more livable. The data will help make Chicago a truly "smart city," allowing the City to operate more efficiently and realize cost savings by anticipating and proactively addressing challenges such as urban flooding and traffic safety[20].

Governments, private utilities and industry have disparate water data sources. Given legal ramifications and privacy concerns around data, **resistance to information-sharing continues**. Further below in the Regulations & Standards section, this paper highlights several international efforts which have successfully promoted open standards and data democratization and transparency initiatives to address the water sector's information sharing barrier.

[17] http://ec.europa.eu/eurostat/documents/42577/3222224/Digital+economy+outlook+2015/dbdec3c6-ca38-432c-82f2-1e330d9d6a24

[18] http://www.innovationendeavors.com/thoughts/israeli-internet-of-things

[19] https://www.ibm.com/news/ca/en/2013/09/18/d784454e42662t01.html

[20] http://www.smartchicagocollaborative.org/about-us/our-model/

Incentives

Incentives used by governments to encourage digital water adoption most commonly take the form of subsidies and grants. **Financial incentives in the form of subsidies and tax breaks have had success in facilitating behavioral changes among water utilities, and in changing public attitudes regarding water reuse.** The same philosophy applies to digital water adoption where rewards and incentives to leverage digital water technologies are often necessary to help utilities implement digital water management. Examples of these types of financial incentives include:

- The **EPA's Water Infrastructure Finance and Innovation Act (WIFIA)** establishes a new financing mechanism for water and wastewater projects, providing low interest rate financing for large dollar-value projects[21].
- **Gateway Water Management Authority**, which serves southeastern Los Angeles Country, in 2015 was awarded a grant under the $1 million category in the WaterSMART Program administered by the US Bureau of Reclamation. The grant funded advanced metering infrastructure and when the installation was completed, the Gateway cities installed all necessary software and worked with the vendor to develop 24/7 real-time computer access for both staff and water customers[22].
- The **2015 Smart Energy and Water Efficiency Act** will encourage innovative solutions supporting digital water systems pilot projects in 3-5 cities. Communities can compete for grant funding to development demonstration projects and to create a "smart grid" for water – detecting leaks as soon as they happen, or even before they happen to save both water and the energy needed to transport and clean it. The bill's accompanying **WaterSense amendment established a "Blue Bank"** to provide grants to help water and sewer utilities invest in water supply management, planning and water efficiency[23].
- The **US EPA** awards grants for environmental agencies to develop programs and platforms that connect and automate data downloads the agency's **STORET Database**, which holds water quality monitoring data for water treatment plants as well as lakes and streams[24].
- In 2006, Israel established **Novel Efficiency Water Technologies (NEWTech)** program, a national program supporting the Israeli water technology sector. NewTech helps to reimburse Israeli water utilities 70% of the installation costs for digital water technologies. The program has proven remarkably successful at facilitating digital water solutions which help the country cope with water scarcity issues[25].
- The **Water Infrastructure Finance Authority of Arizona (WIFA)** is a state agency authorized to finance the construction, rehabilitation and/or improvement of drinking water, wastewater, wastewater reclamation and other water quality facilities and projects. Since 2013, WIFA has helped many communities make digital water investments through low-cost financing and incentives, including offering borrowers below-market interest rates on loans[26].
- The US EPA State-Revolving Fund (SRF) program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a wide-range of water quality infrastructure projects. States are increasingly using the program to finance adoption of digital water technology and management. The SRF program has a distinguished track record of promoting water conservation and reuse in a number of states, including California, Texas, Oregon, Washington and Ohio[27].
- In July, the **Texas Water Development Board** approved two loans to fund water infrastructure improvements in Austin. Austin Water will employ smart meters – allowing customers to monitor leaks and water usage. The loan is one of 15 water plan projects approved by the state in July – financed through the State Water Implementation fund for Texas (SWIFT)[28].

[21] https://www.epa.gov/wifia/learn-about-wifia-program#overview
[22] http://gatewaywater.org/grants/current-projects/smart-water-grant/
[23] http://www.tomudall.senate.gov/?p=press_release&id=2319
[24] https://www.epa.gov/exchangenetwork/exchange-network-grant-program
[25] http://israelnewtech.gov.il/English/AboutUs/Pages/default.aspx
[26] http://www.azwifa.gov/
[27] https://www.epa.gov/cwsrf
[28] http://kut.org/post/city-plans-improvements-water-infrastructure

Regulations and Standards

Governments should promote the use of IoT standards that are developed in an open and collaborative process, including strong industry participation. Open standards are most effective in promoting innovation while ensuring that digital water solutions include robust cybersecurity safeguards.

National governments are adopting open IoT standards which promote data mobility and transparency, paving the way for digital water solutions in Europe and Asia.

For example:

- Denmark's national standardization organization, **Danish Standards (DS)**, is working with the International Organization for Standardization (ISO) and the International Electro-Technical Commission (IEC) on mapping needs and preparing standards for smart cities. DS also collaborates at the European level through the EU "Smart and Sustainable Cities and Communities Coordination Group. Concurrently, the **Danish Business Authority** is developing standards around data sharing for cities—facilitating the country's **National Basic Data** Project which aims to make data from public record more readily-accessible, such as data on properties, companies, water quality and geographic maps[29].
- In 2012, the Singaporean government laid the groundwork for digital water initiatives with its **Open IoT Standards** – a common set of guidelines on ICT requirements and architecture, information and service interoperability, security and data protection. These measures will support sensor data processing and analytics to ensure that data gathered over the network is accurate and intelligently synthesized for making smart decisions[30].

In addition to open standards, regulatory agencies can develop plans and programs for how they will treat, use and protect shared data and other information. Large volumes of data generated in the public and private sectors have high potential to inform broader, regional water management decisions, but they are also vulnerable to improper sharing and handling, as well as other security concerns. Therefore, addressing data protection and privacy is important to ensure safe and efficient critical infrastructure and promote consumer acceptance of digital water solutions. For example, governments can use "privacy-by-design" frameworks, orginally developed with consumer data in mind, in the non-consumer space as well. By proactively embedding privacy into the design and operation of digital water assets, such as treatment plants and distribution networks as well as real-time monitoring networks that connect those assets. Additionally, governments can publish such data privacy standards and communicate privacy controls through public relations efforts to promote consumer acceptance.

According to the Future of Privacy Forum (FPF), a non-profit that explores the challenges of privacy protections in IoT innovation, the path forward for city/community-level IoT adoption, including digital water solutions, is through data and knowledge-sharing, best practices and collaboration[31]. Federal support to local governments can help advance secure, privacy-preserving data sharing. For example, many local utilities lack the institutional resources and knowledge to assess and manage the range of privacy risks that might arise from the employment of digital water solutions. Federal support for a network of city/community privacy leaders and a central repository of common tools, terminology, and training can enable privacy-preserving systems to scale across application areas and geographic boundaries.

Industrial IoT applications, including digital water solutions, have been marked by fast-moving technological developments, raising concerns about the security of critical infrastructure and cloud-based data storage. Given the pace of innovation in different IoT applications, adopting broad-scoped IoT cybersecurity legislation may be counterproductive. Instead, governments might consider adopting internationally-benchmarked, voluntary cybersecurity frameworks that can be tailored to different applications, such as digital water.

For example:

- The **US NIST Cybersecurity Framework** provides a structure that organizations, regulators and customers can use to create, guide, assess and improve cybersecurity programs. The framework is sufficiently flexible to suit water sector cybersecurity requirements[32].
  - In February 2014, the American Water Works Association (AWWA) released the AWWA Cybersecurity Guidance & Tool, a voluntary, water sector-specific approach that supports the NIST Cybersecurity Framework. This guidance provides water utility managers with a concise set of best-practices and standards. It puts forth a transparent and repeatable process for evaluating the security of a utility's process control system[33].

[29] http://www.investindk.com/News-and events/News/2016/~/media/Files/Reports/Growing_Smart_Cities_in_Denmark.ashx
[30] https://www.ida.gov.sg/Tech-Scene-News/Tech-News/Smart-Nation/2016/1/Leading-the-Charge-for-Open-IoT-Standards
[31] https://fpf.org/2017/03/07/fpf-comments-nitrds-smart-cities-communities-federal-strategic-plan/
[32] https://www.nist.gov/cyberframework
[33] http://www.awwa.org/Portals/0/files/legreg/documents/FlyInCybersecurity.pdf

Conclusion

As governments around the world increasingly face water and wastewater infrastructure challenges, many of them are exploring digital water solutions.

This paper provides a menu of policy options that will enable governments to promote more rapid and widespread adoption of digital water solutions. Identifying appropriate policies depends on various factors, including: time horizon for program implementation; governmental structures and processes to communicate and implement such programs; resources, including both funding and expertise; and degree of "buy-in" from stakeholders and policymakers.

While the needs and circumstances of countries, regions, states, cities and local communities vary greatly, the menu presented in this white paper shows that a wide range of policies to promote digital water solutions are being effectively adopted around the world.

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