SMART COMMUNITIES:
Rethinking Infrastructure

ICMA | SIEMENS

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FOREWORD

For almost two centuries, Siemens has been committed to creating perfect places for local governments and the communities they serve by applying ingenuity to solve their toughest problems. Innovation in telecommunications, energy, and the world's first electric train have given us a front row seat to the evolution of today's cities. Local governments are the engines that drive economic growth, climate action, and resilience around the world. As a partner in these challenges, we understand the importance of this report in building education and awareness around energy efficiency and water infrastructure.

In the last five years alone, we have worked with over two hundred local governments in the United States to modernize their infrastructure, resulting in almost one billion dollars in energy and operational savings. We understand that the bottom line for public officials is the need to provide a safe, secure, and prosperous community to keep and attract residents and workers. Energy and water play a starring role in achieving these goals, and these infrastructure assets can be used to provide additional community benefits. We regularly work with communities to leverage infrastructure modernization in STEM education programs, workforce development opportunities, stimulating the local economy, and encouraging and mentoring small and diverse business enterprise. City or town, large or small, we help communities modernize buildings, increase public safety, and meet energy goals to create smart and resilient communities of the future.

We are honored to partner with ICMA to support this report and continue our commitment to the profession and the citizens they serve.

Regards,

Peter Torrellas
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Executive Summary

Cities and counties are deploying smart cities applications to support energy, water, and wastewater operations. According to a 2016 survey conducted by the International City/County Management Association (ICMA) in partnership with the Smart Cities Council, 38.7 percent of communities have smart cities applications in active deployment in the energy sector, while 37.5 percent have smart cities applications in active deployment in the water and wastewater sectors. Additionally, nearly a third of communities—29.7 percent—cited the water and wastewater sector as their top smart cities priority.

While the energy and water sectors may garner less attention than other areas of the smart cities conversation, such as autonomous and connected vehicles, they provide great opportunities for the deployment of smart cities applications. This report looks at smart cities technologies that communities are deploying across the energy and water sectors and examines challenges—some unique to these sectors and some that apply more broadly across smart cities applications. This report draws on interviews with cities and counties that are deploying these technologies, and four case studies—Boulder, Colorado; Cambridge, Massachusetts; Sacramento, California; and Arlington, Texas—illustrate specific examples of smart cities applications in the energy and water sectors.

Defining the Smart City

The Smart Cities Council defines a smart city as one that "uses information and communications technology (ICT) to enhance its livability, workability, and sustainability." It further defines the functions of a smart city as collecting, communicating, and "crunching": collecting information through the Internet of Things (IoT) on current conditions and operations within the community; communicating that data over wired and wireless networks; and "crunching" or analyzing the data to improve efficiency and inform decision making.[1]

Big data analytics—the process of summarizing data, converting it into metrics and indicators for processing, and integrating and contextualizing that data to provide conclusions and communicate findings[2]—can help cities better understand the services they provide and how those services are being used. These data can then be used to drive decision making that makes operations more efficient, improves service delivery, and has an overall positive impact on community quality of life. In this sense, the smart cities technologies that communities are deploying should not be thought of as an end in and of themselves, but as a means to achieve broader community goals.

Antonia Graham, assistant to the city manager/energy and sustainability in Huntington Beach, California, summarized it as, "At the end of the day, a smart city is a city that works for everyone, that uses technology to improve business services, to make life better for its residents, and for improving its own functions."

Why This Matters for Your Community

The use of smart cities technologies in the water and energy sectors has many benefits that are not unique to these sectors or to the specific technologies that are deployed to support their operations. This includes priorities identified as important or very important in the ICMA/Smart Cities Council survey, including resiliency for critical operations (81 percent); operational cost savings (81.8 percent); and making local governments more responsive/enhancing resident services (79.9 percent).

There are also benefits related to deploying smart cities technologies in the energy and water sectors that are more specific to these sectors. These include achieving climate, energy, and sustainability goals and addressing challenges related to aging infrastructure and the infrastructure financing gap. Finally, there is a water-energy nexus, and increasing efficiency in one sector can impact use and efficiencies in the other.

Achieving Climate, Energy, and Sustainability Goals

Smart cities applications in the energy and water sectors are important tools for achieving and demonstrating progress towards climate, energy, and sustainability goals. Many communities have adopted climate action or climate adaptation plans that have goals related to reducing greenhouse gas (GHG) emissions through strategies including energy efficiency and clean energy. Communities also have goals, policies, and actions in their comprehensive plans related to energy and water. Smart cities technologies can help with progress toward the implementation of these plans, as well as tracking and benchmarking progress towards related goals. Communities can share these data through open data portals and data dashboards, making them available to residents for review and analysis.

Aging Infrastructure and the Infrastructure Financing Gap

Much of the infrastructure across the United States is reaching the end of its useful life. The American Society for Civil Engineers (ASCE) 2017 Infrastructure Report Card gives American infrastructure a grade of D+. Energy and water infrastructure are graded at or below this average, and persistent funding gaps are forecast in both sectors. The ASCE report estimates the investment gap in electricity infrastructure, much of which has met or exceeded its fifty-year life expectancy, between 2016 and 2025 to be at $177 billion, while the water and wastewater sectors need $150 billion.

Smart cities applications can't meet all the infrastructure-related needs in the energy and water sectors; however, they can help cities and counties make efficient use of limited resources and prioritize key investments in energy and water infrastructure. Real-time monitoring can detect problems in the systems, such as equipment failures, leaks, or contaminants, and alert analysts and technicians, preventing losses. Currently, an estimated $2.6 billion is lost every year as water mains leak treated drinking water.[3] Non-revenue water (NRW) that includes water lost to leaks, results in the waste of an important resource, particularly in water-scarce regions, and prevents utilities from realizing revenue that can be reinvested in their systems. Data analysis can inform models and forecasts that help predict system performance and potential areas of vulnerability or failure, which need to be prioritized for investment or repair, preventing losses and potential impacts to the public from failures, such as water main breaks.

Improving Resource Efficiencies between Sectors

A nexus exists between the energy and water sectors. The energy sector is a large consumer of water resources, while the water and wastewater sectors are significant consumers of energy. Power plants rely on water for cooling, and thermoelectric power plants use steam to generate electricity. Water use in the power sector was four times higher than the residential sector in 2005,[4] creating stress on water supplies. Meanwhile, water systems may account for up to 50 percent of a community's energy costs.[5] This creates significant interdependencies between these sectors. The use of technologies that improve the efficiency of operations in one can have significant impacts in the other. For example, it is estimated that optimizing water treatment with smart cities technologies can reduce energy usage by up to 30 percent.[6]

Benefits and Barriers to Smart Cities Technology Deployment

The energy and water sectors have long been data-driven and technology-focused. Reliable energy, safe and affordable drinking water, and wastewater treatment play essential roles in the everyday life of communities, and failures in these systems pose threats to community health and resilience.

"You can't operate a complex system without technology and the ability to manage large amounts of data," Jeff Arthur, director of public works for utilities for the city of Boulder, said of its use of these technologies.

As with benefits, many of the barriers or challenges that communities face related to the deployment of smart cities technologies in the energy and water sectors are not unique to these sectors. The most significant barrier cited in the ICMA/Smart Cities Council survey was budget limitations (75.4 percent).[7] As communities look to deploy smart cities technologies, they are not only facing challenges financing projects, but also a need to look at changes in the way that costs are considered when looking at projects that may have high upfront costs, but create greater efficiencies over time. Communities are also facing challenges related to internal capacity (61.1 percent) and technical expertise (40.2 percent).

There are also challenges that are more unique to the energy and water sectors, including the need to work with public utilities and data security concerns. Nearly 70 percent of electric customers in the United States are served by public (investor-owned) utilities.[8] This may limit the ability of a community to expand energy-related efforts beyond city facilities and operations and can pose challenges to accessing data collected by the utility on community-wide energy usage.

Data privacy and security concerns, which exist across smart cities applications, are also paramount when it comes to smart cities applications for energy and water. The energy, water, and wastewater sectors represent critical infrastructure, and data generated include information about system vulnerabilities.

Smart Cities for Energy

Communities are implementing technologies that improve energy efficiency, increase the use of renewable sources, and improve system reliability. Many of these technologies, like smart and connected buildings and energy-efficient intelligent streetlights, focus on city operations. Others, such as smart grid and microgrid technology, focus on reducing the vulnerability and improving the resiliency of the electric grid.

Smart Grids and Microgrids

The smart grid refers to technologies that work with the electric grid to monitor conditions and respond in real-time to shifts in demand. These include smart meters on the consumer side. Smart grids increase the efficiency of electricity transmission and improve reliability by allowing for more timely restoration of service. They also allow for the isolation of a portion of the grid when outages do occur, preventing cascading effects that lead to larger blackouts.9

Isolating a section of the grid is enabled by microgrids. A microgrid "is a localized grouping of electricity sources and loads that normally operates connected to and synchronous with the traditional centralized grid (macrogrid), but can disconnect and function autonomously as physical and/or economic conditions dictate."[10] Boulder, Colorado, is piloting microgrids in order to better understand how they function both in isolation and in connection to the macrogrid, as well as what economic, environmental, and social benefits may result from the use of this technology.

A key benefit of a smart grid is the increased effectiveness of renewable energy. The variance associated with renewable energy sources such as wind and solar had traditionally been a challenge with aging grids. The smart grid allows operators to monitor both supply and demand and use load shifting (real-time demand management) to smooth out peaks in electricity demand.[11] Smart grid technologies can also tie in with smart building technologies, including energy management systems and smart appliances, to optimize energy use and reduce peaks.

Smart and Connected Buildings

Communities are updating their facilities with smart building control systems that optimize building performance. These systems control heating and cooling systems, lighting, and mechanical and electrical systems. They allow for real-time monitoring of energy usage and system performance and can adjust energy usage to building conditions and allow for direct digital control, monitoring, and detection of issues. The use of smart technologies to optimize building performance reduces both operations and maintenance costs.

Cambridge, Massachusetts, has fifty-four city facilities connected by a fiber network. Twenty-nine of these buildings have direct digital controls that allow for optimization of operating efficiency and life of service equipment, and facilitate the prompt diagnosis and resolution of problems when they arise.

Energy-Efficient Intelligent Streetlights

Many communities are converting to energy-efficient intelligent streetlights, retrofitting their streetlights with LED bulbs. These streetlights can also be paired with upgrades that allow for remote management, which adjusts lighting to be adaptive to conditions and provide notification of outages. They can also be paired with other sensors that monitor conditions, such as weather and traffic.

Huntington Beach, California, began negotiations in 2014 to acquire 11,000 streetlights owned by its electric utility, Southern California Edison. The city saw these streetlights as essential infrastructure for becoming a smart and connected city. The acquisition will allow the streetlights to be retrofitted with LED lighting, producing a significant savings on energy costs ($14 million over twenty years when combined with the retrofit of the 2,300 lights already in the city's ownership), as well as for the deployment of other smart cities applications, including small cells, meter reading technologies, and announcement systems within the tsunami zone.

Electrification of the Transportation System

Communities are considering smart energy technologies as they apply to the transportation sector. These include two major areas: electric vehicle (EV) network infrastructure and electrification of public transportation.

EV network infrastructure consists of the publicly accessible charging stations used to recharge electric vehicles, as well as the applications that allow drivers to find the charging stations. A reliable network of charging stations is essential to increasing the adoption of EVs. Multiple companies are partnering with local governments to deploy charging stations, many of which currently allow users to charge for free.

Arlington, Texas, partnered with Tesla to build the first urban Supercharger station in the Dallas-Fort Worth Metroplex. The station has ten Superchargers and is located near Interstate 30 and Arlington's Entertainment District.

For public transportation, electrification includes both the transition of the fleet to electric vehicles and the installation of the necessary charging infrastructure. In Boulder, Colorado, the city and Via Mobility Services received a grant in 2017 to support an electric bus and charging infrastructure.[12] The city is looking at the future potential for electrification of the entire fleet and at related battery applications, examining how the batteries used to power the buses could be used as a power supply for sheltering sites during emergency events.

Smart Cities for Water

On the water supply side, smart cities technologies play an important role in reducing NRW. In addition to reducing revenues from unrecovered rates, NRW requires water utilities to treat and pump more water to meet water supply needs. This results in increased costs related to labor, chemicals needed for treatment, and energy consumption. It can also put pressure on water supplies, which are becoming scarce in many regions. Implementing technologies that help track and monitor water usage more accurately, detect leaks, and allow for real-time data monitoring can help reduce losses throughout the system. Reducing NRW using smart cities technologies can also prevent the need for rate increases.

Boulder, Colorado, has compiled a database of water pipes throughout the city, which includes information on the date of installation, age, break history, and material. These data can be used to predict which pipes are most likely to fail so that they can be replaced before they do, reducing the public impact.

Automatic Meter Reading

Automatic meter reading (AMR) or smart metering technology automatically collects data on water or energy usage from customer meters and transmits that data to the utility's database for billing and analysis. AMR technology increases the frequency and accuracy of meter reading and can be used to detect leaks, reducing NRW.

In 2004, Montgomery County, Ohio, began replacing water meters for its 80,000 customer accounts with AMRs. This transition, which was completed in 2016, has reduced calls and field visits related to billing questions. It has increased the accuracy of customer billing by reducing human error—field technicians can't misread meters or transpose numbers. Records of hourly usage are stored for 93 days, which helps resolve customer billing questions and concerns. It has also increased staff efficiency, now taking one person two days to complete meter readings that were previously done by five people over several weeks.

SCADA Systems

SCADA, or supervisory control and data acquisition, refers to a multilevel control system architecture that consists of both hardware and software. It gathers data from field devices, monitors and processes data in real time, and allows for remote monitoring and control of systems. The complexity of SCADA systems varies. This systems architecture is used in multiple sectors, including by water supply, stormwater, and wastewater utilities.

In Portland, Maine, the water resources team fully committed to using a SCADA system. The team is able to remotely monitor the stormwater and sewer systems.

Technicians are able to see data in real time and to operate the systems from their smartphones. This allows them to rapidly detect and respond to problems within the system, such as a pump malfunction, and to provide immediate maintenance before problems become more severe.

Community Engagement

Energy and water utilities deliver essential services to residents every day. However, people often don't think about or engage with them unless there is a problem—such as an issue with their monthly bill or a water main break on their street. The use of smart cities technologies produces vast amounts of data that can not only inform operations, but also offer opportunities to positively engage residents around energy and water (and even wastewater!).

For some communities, this opportunity to engage with residents is a primary driver behind the adoption of smart cities technologies. "The primary drivers are to interact with the public more efficiently, to provide information to the public, receive information from the public and about the public, and provide it back to the city," said Troy Moon, Portland, Maine's sustainability coordinator, of the drivers behind the city's deployment of smart cities technologies. "We aim to improve services and strategize maintenance plans, and basically learn how we can better respond and practice proactivity in our programs."

To do this, it is important for communities to effectively communicate data to the public. Data dashboards can provide a tool for visually displaying key metrics and indicators, such as energy consumption and percentage of renewables in a way that makes the data easily accessible and digestible. Open data portals can also be used to make energy and water data sets available to the community, increasing transparency and providing opportunities for residents to engage with and analyze these data. Community members and companies can also use and combine the data to build applications.

In addition to sharing data with the community, cities and counties can use crowdsourcing techniques to gather data from the public. Crowdsourcing can be used to identify both problems and solutions and can be an effective tool for gauging community sentiments about potential projects or policies. It can also be used (as a smart cities strategy itself) to engage residents around defining goals for smart cities applications in the energy and water sectors.

"How do we use these smart cities strategies to engage, participate, and work with our community members in a more effective manner?" Jonathan Koehn, environmental affairs manager, said of community outreach around Boulder's energy-related smart cities efforts. "This an area which has been brought into focus…how the city can do a better job of working with stakeholders and community members, and how we can lean on our partners and experts at the same time."

What We're Learning

The energy, water and wastewater sectors are sectors where communities are actively deploying smart cities technologies, including smart building technologies, energy-efficient intelligent streetlights, AMRs, and SCADA systems. They also represent areas of high potential for continued deployment of these technologies. The ICMA/Smart Cities Council Survey and the follow-up interviews with communities offer some insights and lessons learned:

- **Smart cities applications require partnerships.** Smart cities applications for energy and water are inherently cross-disciplinary and require communication and collaboration across departments. These applications rely on a robust IT architecture, and may impact operations that fall under the jurisdiction of multiple departments, including public works, public safety, sustainability, and transportation. They can also benefit from external partnerships, which can help leverage additional resources, support data analytics, technology transfers, and pilot projects. Cambridge, Boulder, and Arlington are partnering with local universities. In Cambridge, the city is working with local technology companies, and in Boulder, the city is working with the nearby federal laboratories.
- **Technical expertise is essential.** As new technologies are deployed, it is important to invest in staff training and make sure that there are people who fully understand how to use the technologies and related applications. This helps ensure that the smart cities technologies are used to their fullest potential, as well as that issues can be addressed when they arise. "Technology is great until it's not. You need to have the right team to address those issues when they arise and the skills they need to fix

it," said Cathy Peterson, the director of communications for Montgomery County, Ohio.

- **Smart cities technologies have multiple co-benefits.** The energy-water nexus makes the connections between investments in energy and water infrastructure clear—technologies that improve systems operations and increase performance in one sector can create efficiencies in the other. Other co-benefits may be less clear, but are worth examining when investing in smart cities technologies for energy and water. These include the impacts of energy-efficient intelligent streetlight retrofits on public safety and of EV infrastructure on transportation. Looking at data across platforms and functions can help identify these synergies.
- **Smart cities technologies are continuing to evolve.** As communities are actively deploying smart cities technologies—nearly 40 percent of communities have deployed these technologies to support their energy, water, and wastewater operations—these technologies are continuing to evolve. New generations of the products will offer new and improved functionality, as well as new challenges. They will also require continued investment, as will any other form of infrastructure. "The smart city sector is a constantly developing field," said Troy Moon, the sustainability coordinator in Portland, Maine. "We do acknowledge that different people will have different definitions and expectations about what they want to provide to the residents and what elements to deploy in their cities. We are trying to be thoughtful in our approach with respect to technology…There are going to be lots of changes and new opportunities to look forward to in the coming years."

The following community profiles provide a more in-depth look at cities making progress with water and energy smart technology applications. These profiles offer insights and lessons about the challenges and opportunities from these new technologies. Local governments are helping communities become better places to live because they are using smart technologies to engage more with the community, to use resources more efficiently, and to deliver the services the community wants.

SMART COMMUNITY PROFILES

Boulder, Colorado

COMMUNITY PROFILE

2016 Population Estimate: 108,090

Median Household Income: $58,484

Area (in sq. miles): 25.85 (66.95 km²)

Source: United States Census Bureau

Boulder is located northwest of Denver, in the foothills of the Rocky Mountains. Long known for its commitment to sustainability, the city sees smart cities applications as key to advancing its sustainability goals, including those related to energy and water. "When we talk about smart cities applications, it's a way to empower sustainability—meaning, a smart city is a sustainable city," said Jonathan Koehn, Boulder's environmental affairs manager. "Resilience has been a growing concern for a lot of communities in Boulder—how can we use technology not just to strengthen our systems, but also how do we think about technology to strengthen our community in general?"

The city has hired a chief innovation and analytics officer and is building connections between the innovation team and the existing work in IT, resilience, and sustainability, as well as looking at how activities that can already be categorized as smart cities applications can be connected through a strategic approach. Boulder is a participant in What Works Cities, a Bloomberg Philanthropies initiative designed to help midsized cities effectively use data to improve local government services. Boulder has also joined Colorado Smart Cities Alliance, a multijurisdictional initiative coordinated by the Denver South Economic Development Partnership to promote the deployment of smart cities technologies across Colorado.

Boulder is currently working to develop its smart cities strategy; however, the concept is broadly addressed in the current update of the Boulder Valley Comprehensive Plan—the joint comprehensive plan for the city and county of Boulder—though goals and policies related to energy, climate strategies, and information technology. The plan also highlights the need to develop comprehensive strategies around smart cities applications.

Energy

Energy has been one of Boulder's top priorities for nearly a decade. The city's efforts on energy have a strong focus on analytics. Boulder has been using energy use data to help understand whether to place the emphasis on the demand side or the supply side to drive reductions in energy usage. For example, the city is conducting a neighborhood-scale assessment of real-time energy use mapped to every building within the city, which will allow for evaluation of the potential benefits and impacts of transitioning residential, commercial, and industrial buildings off of natural gas and when those transitions should be made.

Boulder currently has several pilot projects focused on microgrids underway. Through these pilots, the city is working to define the benefits of microgrids and how energy storage may play a role, with a focus on solar photovoltaic (PV) onsite generation. One pilot is on the University of Colorado at Boulder campus and is being used to understand how an islanded area functions and communicates with other microgrids within the city, as well as what benefits (social, economic, and environmental) it may be able to provide back to the system.

This work on microgrids has tied into another area where Boulder is deploying smart cities technologies to address energy usage: the transportation sector. One of the microgrid projects is conducted in partnership with Via Mobility Services, which is a local transportation provider for senior citizens and people with disabilities. Via is a key responder during emergencies and needs to maintain power for communications and dispatch systems. The microgrid can help provide a high level of resilience at Via's facilities. It has also helped Boulder begin to consider future opportunities around electrifying a few bus routes and how the batteries in the buses could also be used during emergencies to effectively plug in and power critical facilities.

Boulder's transportation master plan includes strategies related to reducing vehicle miles traveled and electrifying the transportation system. It helps create a learning laboratory vision around future energy use and address a major component of the energy challenge, which is the use of petroleum for transportation. The city is also using the data, analytics, and technology available to begin thinking about the role that autonomous vehicles (AVs) may play, and how this may impact other areas of energy and consumption, which may in turn affect how the city approaches building requirements and parking regulations.

Boulder's use of data and analytics, including smart sensing technologies and real-time data tracking, to understand how to best shape energy usage has also led to more innovative and aggressive building codes. Nearly half of all Boulder's housing stock is rental property and, as a result, the city worked to understand needs related to energy efficiency in rental properties and enacted the nation's first energy efficiency requirements for rental housing.

The SmartRegs ordinance, which requires rental housing to meet an energy efficiency standard by December 31, 2018, is critical to making progress toward social and environmental sustainability goals. The city has also adopted the Boulder Building Performance Ordinance, which requires new and existing commercial, industrial, and city-owned buildings to rate and report on annual energy usage and to perform energy assessments every ten years. Data was essential to building community support for these requirements.

Many of Boulder's investments related to energy have been capital projects, but the city is pursuing other ways to finance projects, including grants and partnerships with the federal laboratories and the University of Colorado at Boulder.

Water

Boulder's work to use smart cities applications to address water starts at the energy-water nexus, using the technology and data generated to think about strategies to achieve broader community objectives. The city, which currently has a cogeneration facility at the wastewater treatment plan, is looking at options that would allow it to pipe natural gas to a central location to fuel natural gas vehicles. Additionally, the city owns and operates eight hydroelectric facilities and is looking at ways to use pumped hydro storage to shape peak demand and impact the economics of local energy usage.

Boulder has also been using data to address flood management. The city is part of the Urban Drainage and Flood Control District, a regional flood control district, which draws funding from multiple sources including a property tax levy. This regional partnership allows for regional data sharing and the development of resources that all participating jurisdictions use. The flood control district manages an integrated network of rain and stream gauges throughout the region and contracts with a custom meteorological service. It also has a common data network that is used for communication during hazard events and severe weather forecasts. The data sharing and integration enabled by this regional partnership facilitates responses to flood events in ways that would not be possible if each jurisdiction were looking at their data in isolation.

Boulder experienced significant flooding during the 2013 Colorado floods. Following these floods, during which all fifteen drainageways that run through the city overflowed, Boulder reevaluated its floodplain modeling, which primarily considered flash flooding along a single drainageway. This flood event provided a massive amount of rainfall, stream gauge, and weather data. The city also crowdsourced data about damage caused by the flooding, using surveys, public meetings, and online input to collect information and observations. All of these data were used to fine tune and revise the city's flood hazard maps, creating an interactive map of flood hazard zones. These improved maps have, in turn, informed mitigation strategies.

Boulder also saw an increase in public interest in water infrastructure following the 2013 floods. The city has created an interactive web tool that provides residents with information on water main breaks, pipe conditions, areas prioritized for updates or replacement, and progress related to implementing the system rehabilitation program.

Boulder's water utilities work as enterprise funds, supported by water rates and fees including monthly stormwater and floodwater charges. This funding is used for related purposes, including to support technology that improves water supply, stormwater, and wastewater management.

Challenges

Boulder has experienced challenges that are both general to smart cities applications and those that are specific to the energy and water sectors in their deployment of smart cities technologies.

One challenge that the city has faced related to energy is that Boulder is served by an investor-owned utility (Xcel Energy). This limits its ability to deploy technologies aimed at providing customer choice; monitoring usage in real-time and providing this information to businesses and residents; deploying innovative technologies aimed at minimizing energy consumption; and increasing use of clean and alternative sources of electricity, which require the approval of the existing utility. Boulder is currently working to municipalize its electric utility in order to provide a platform of innovation and create a model of the utility of the future.

Another challenge related to water and energy is that there often is not a lot of public interest in utility-related applications until there is a problem and, as a result, people are somewhat selective in their interest in the data. Raw data are not necessarily something that people have the time, interest, or expertise to sort through. As a result, it is important to take the time to figure out what part of the data is most meaningful and tell the story in a way that residents can understand and engage with. It is also important to leverage opportunities when people are most interested and engaged around a topic to share that data.

Takeaways

In Boulder, smart cities technologies are viewed as a tool that can help achieve community goals and improve decision making. Koehn describes Boulder's smart cities efforts as "in the short term, understanding the clear nexus between the city and organization-wide objectives: how to effectively make better decisions and empower decision makers with the best information, how it supports our sustainability efforts, whether it's providing incentives, helping citizens be good stewards, and how technology can create a more resourceful culture within the city."

Jeff Arthur, the director of public works for utilities, also emphasized that smart cities applications are focused on the outcomes they help the community achieve. "Are utilities actively using data to make decisions and inform the public? Then that's absolutely true. It's less about gadgets and flash and more about reliable systems that can work 100 percent of the time because it does not work to not have water or sanitation. The systems are aligned with the vulnerabilities."

In order to achieve these goals, Boulder has embraced partnerships with universities, local federal partners, and other jurisdictions within the region. These partnerships help extend the understanding of challenges and how these applications can play a role in solving them; provide an opportunity to learn from other jurisdictions, as with What Works Cities; and can be a useful tool for leveraging and sharing resources, as with the cases of the Urban Drainage and Flood Control District.

Boulder's experience with smart cities applications in the energy and water sectors also shows the importance of engaging the public, whether that is by using data to effectively tell a story and communicate the need for a program or regulation or by gathering data from the community to help inform an outcome.

Interview Participants

Jonathan Koehn
Environmental Affairs Manager, City of Boulder, Colorado

Jeff Arthur
Director of Public Works for Utilities, City of Boulder, Colorado

SMART COMMUNITY PROFILES

Cambridge, Massachusetts

COMMUNITY PROFILE

2016 Population Estimate: 110,651

Median Household Income: $79,416

Area (in sq. miles): 7.13 (18.47 km^2)

Source: United States Census Bureau

Cambridge, located on the banks of the Charles River, is home to Harvard University and the Massachusetts Institute of Technology, as well as a number of major technology, biotechnology, and pharmaceutical companies. The city sees smart cities technology as a driver of efficiency and productivity, which together allow for the provision of better services.

Cambridge has a commitment to open data and the tracking of sustainability data. The city has an established Open Data Portal, which makes data available in easy-to-find and usable formats, therefore creating meaningful opportunities for the public to help solve complex challenges. The city also has dashboards, like the Green Building Dashboard, which display progress towards sustainability goals.

Smart cities applications are centralized within the city's IT Department, which plays a coordinating role as "the backbone." The respective departments then undertake the responsibility of implementing the individual technologies. A defined smart cities strategy has been identified as a need, and the city has worked to define the key areas and challenges; however, Cambridge does not currently have specific goals and objectives focused on adoption of smart cities applications.

Smart cities applications related to energy and water, including the installation of LED streetlights and automatic water meters, and the direct digital control of the buildings, have been high-impact investments for the city.

Energy

Cambridge is working toward becoming a net zero community. The city's Net Zero Action Plan, adopted in June 2015, sets a goal of reducing greenhouse gas emissions from buildings citywide to zero over a twenty-five-year period. These efforts are tracked through the city's online building data dashboard. The city has adopted a Building Energy Use Disclosure Ordinance that requires energy usage for all large buildings—which account for two-thirds of the GHG emissions in the city—to be tracked and reported. These data are posted to the Open Data Portal.

To address energy usage in city facilities, Cambridge has installed direct digital-control building management systems in twenty-nine city facilities. These systems have 50,000 object points managing 2.3 million square feet of space and provide remote access to HVAC systems. The city utilizes them for equipment control, monitoring, scheduling, and related energy management tasks with the intent of providing high-performing building control systems. This ensures that facilities are operating at peak efficiency, optimizes the life of service equipment, and prevents systems failures. It also directly alerts staff if part of the system is down, which allows for prompt diagnosis and resolution of the root causes of control problems.

The city has also converted 6,000 street and park lights to LED lights. This conversion increases energy efficiency and reduces the staffing capacity required for routine maintenance through remote monitoring capabilities. The remote monitoring allows the lights to be dimmed to meet lighting requirements and maintain energy efficiency (they are dimmed to 35 percent utilization at 2:00 a.m.) and has added significant energy savings, while also addressing other relevant issues such as comfort, safety, security, and visibility on a given street. It also increases operational efficiency—prior to the transition to LED lights, locating a nonfunctioning streetlight required maintenance staff to drive around and find the light, whereas now remote sensors notify staff when a light is out.

Water

Cambridge has been integrating smart technologies focused on water usage and stormwater and wastewater systems for over a decade. Since 2006, Cambridge has had automatic meter reading (AMR) for water customers. The AMR system conducts multiple readings per day and notifies customers of high water usage twice a week. The city is also developing a user interface—to be implemented by the end of 2017—that will allow users to monitor their own water usage.

More recently, the city has started installing automatic irrigation systems. These systems, which are networked and controlled remotely, monitor the soil's moisture content along with other factors relevant to irrigation, and self-optimizes its functionality.

Cambridge has also implemented real-time monitoring of its stormwater outfalls and sewer and stormwater pump stations using a SCADA system. The city has water quality monitoring at four outfalls, as well as multiple locations for real-time monitoring of sewer and stormwater pump stations and drainage systems. The deployment of these technologies, which facilitate remote control and monitoring in real time, allows the city to more effectively manage stormwater events, controlling releases and mitigating flooding. The data collected from these monitoring stations are also used to study stormwater outfall quality in the case of combined sewer overflow (CSO) events, which allows the city to monitor the quality of water going into the Charles River and Alewife Brook over time. Having these data then allows the city to take actions and adjust functions to improve the quality of those waterways.

The city is also in the process of implementing and upgrading the variable frequency drives at the water treatment plants. This upgrade will include remote pump monitoring to prevent unanticipated failures, and will also result in significant energy savings.

Challenges

Cambridge has faced several challenges related to the deployment of smart cities applications. These include integrating smart technologies into legacy systems, and the fact that there are not always clear cost savings, even if the technologies provide better services to citizens. This can include both the initial costs of deploying the technologies, as well as the ongoing operational costs.

The city has also identified a need for skilled workers who understand and can use and maintain the technology and can ensure that it works to its potential. In practice, this results in a need for a point person who is knowledgeable about each application and who can work with the vendors, citizens, staff, and multiple departments to resolve challenges that arise when deploying new technologies.

There are also challenges related to data privacy and context. Related to data context, there are many large energy users in Cambridge, such as biotechnology labs. The city has worked to provide context around energy use for these types of facilities in the open data portal so that data consumers do not view the large energy use numbers as a negative without the proper context.

Takeaways

Cambridge's use of smart cities applications highlights the co-benefits that exist and the need to evaluate investments accordingly. For example, installing LED streetlights has benefits related to energy efficiency, public safety, and operational efficiency. Upgrading the equipment at the water treatment plant allows for better monitoring, which helps prevent unanticipated failures, and also results in significant energy savings.

Cambridge's experience also illustrates that it's not just the adoption of the technology, but how the data generated from the deployment of that technology are used to increase efficiency and improve service delivery. "We need to focus on meaningful and relevant data in order to better organize our services, improve data security, and resolve privacy issues," said Lisa Peterson, deputy city manager, of deployment of smart cities applications. "We do want to understand the unintended consequences—what all this data is, to ensure the correct methods of use are undertaken and again, are we doing it in the 'smart' way."

Finally, Cambridge's experience highlights the importance of partnerships and public engagement. In May 2017, Cambridge held a city-wide forum to educate the community about smart cities applications, with the goal of building engagement, consensus, and collective management around these technologies. The city is partnering with Gartner and the Massachusetts Institute of Technology, as well as residents, to think collectively about these issues and build better programs, and to address issues of governance, data security, and costs associated with technology.

Interview Participant

Lisa Peterson
Deputy City Manager, City of Cambridge, Massachusetts

SMART COMMUNITY PROFILES

Sacramento, California

COMMUNITY PROFILE

2016 Population Estimate: 495,234

Median Household Income: $50,739

Area (in sq. miles): 100.11 (259.27 km^2)

Source: United States Census Bureau

Sacramento is the capital of California and a "small big city," located in the Central Valley. The city's focus on smart cities applications first catalyzed around the U.S. Department of Transportation's Smart Cities Challenge. Through the process of applying for the Smart Cities challenge, the (now previous) director of public works formed a staff working group to work on defining what it means to be a smart city, and on identifying key challenges, partners, and focus areas. This resulted in city staff developing a concept of a smart city that goes beyond technology and process to focus on solutions and the use of new applications that benefit citizens and improve local quality of life. It also resulted in an understanding of the sizeable role that technology has to play in addressing local challenges and providing for growing demands with limited resources.

The city has continued this conversation and worked to understand what it already does that qualifies as a component of a smart city. This city has conducted an internal inventory in order to better understand these applications, including innovations in the utilities department and waste management, and technologies deployed through the IT department.

Sacramento does not have an adopted smart cities strategy or goal; however, it does have broad context supporting deployment of smart cities technologies from the 2035 General Plan, which has as its vision making Sacramento the most livable city in America. There is strong political support behind smart cities applications, and they are closely related to other priorities being implemented across departments.

Energy

Sacramento uses an energy management system through EnergyCAP. Through this system, a semi-automated process is used to upload electric and natural gas bills for all city facilities on a monthly basis. All city departments have access to these data, which allows for the tracking of energy usage, as well as the identification of problems and needed updates. All the departments have access to them. These data have helped identify and prioritize needed updates to electrical systems. The city also uses ArcFlash to inventory energy usage and track surges. Investments in energy management systems have been funded through the general fund.

The city is working with the Sacramento Municipal Utility District (SMUD) to install solar capacity. Currently, it has 4.9 megawatts of grid-connected solar PV capacity on city facilities. Through this partnership with SMUD, the city has also installed telemetric systems, which allows for real-time monitoring of the solar PV systems and their performance. The solar PV installations were funded by a grant through the American Recovery and Reinvestment Act, while the monitoring systems were funded by SMUD.

The city is also investing in infrastructure for electric vehicles. This includes installation of new chargers and upgrades to aging infrastructure with technology that allows for the metering of use at each charger. This will allow the city to claim credits with the California Air Resources Board, which will result in monetary benefits. The city has entered into a no-cost public-private partnership, which leverages city assets in exchange for services, to finance investments in EV infrastructure.

Challenges

Sacramento has addressed several challenges in the process of deploying smart cities applications. These challenges have been applicable across sectors and are not specific to energy. The use of these applications requires the city to look at risk differently and requires staff to take a different perspective on roles and how functions coordinate or align across departments. It also means defining success (including indirect benefits) in new ways, and effectively using the data generated to monitor operations, understand service needs, and report on outcomes.

Another challenge is the universe of opportunities that exist related to smart cities applications. Sacramento is continuing to work to better understand and prioritize opportunities and to find the balance between testing applications that may provide benefits for the community and not overextending resources in doing so.

Takeaways

Sacramento's experience highlights the importance of taking time to define what it means to be a smart city and how goals and priorities related to the adoption of smart cities applications connect to larger community priorities, such as goals in a comprehensive or general plan.

It also highlights the role of innovative public-private partnerships to help deploy smart cities technologies. In addition to the partnership for the EV charging stations, the city has entered a public-private partnership with Verizon to pilot 5G infrastructure. This will include installation of intelligent transportation systems at twenty-six intersections, WiFi in twenty-five public parks, and WiFi kiosks with wayfinding in the downtown. The city will receive 20 percent of the revenue from the advertisements on the WiFi kiosks.

Finally, Sacramento's experience highlights that city facilities are the low-hanging fruit when it comes to implementing smart cities technologies that support climate, energy, and sustainability goals. "It's harder for the community and that's where a lot of our climate targets are going to push us to go farther than we can go right now," said Jennifer Venema, Sacramento's sustainability program manager. "We will be challenged to understand energy trends, developing policy solutions to mitigate that. We are going to have more challenges. We are good at the municipal side but we have more to do on the energy side."

Interview Participant

Jennifer Venema
Sustainability Program Manager, City of Sacramento, California

SMART COMMUNITY PROFILES

Arlington, Texas

COMMUNITY PROFILE

2016 Population Estimate: 392,772

Median Household Income: $53,326

Area (in sq. miles): 99.7 (258.2 km^2)

Source: United States Census Bureau

Arlington, located in Tarrant County and part of the Dallas-Fort Worth Metroplex, is known as the home of the Dallas Cowboys and Texas Rangers. The city is also home to the University of Texas at Arlington; the Nuclear Regulatory Commission Region IV; and the headquarters of large companies, such as Texas Health Resources and D.R. Horton, and the high IQ society, American Mensa. Arlington is part of the What Works Cities initiative, a program Bloomberg Philanthropies designed to enable data identification, collection, and sharing across city operations in mid-sized cities.

Arlington does not have a specific smart-cities plan or strategy, but has made significant efforts to embrace smart technology across its operations. The city council champions and inspires neighborhoods to embrace technology. From social decisions to capital allocation and human resources, Arlington focuses on using data to make informed decisions, diverging from a strategy of making decisions based on past practices or common knowledge.

The primary driver behind the adoption and deployment of smart cities applications in Arlington is leadership and support from its city manager and elected officials, including members of the city council and the mayor, who have made it a high priority. The city manager's office has taken a leadership role, and pulled together a team within the city government. In addition to having an effective team, the city is part of the economically vital Metroplex region, where growth creates a constant demand for services. Furthermore, regular communication and engagement within the management has supported optimization of existing resources.

Water

Arlington has embraced a new technology in the last couple of years that allows instrumentation to be installed in water and sewer lines for pipeline evaluation. The city's partnership with the University of Texas, Arlington, includes this project, the purpose of which is to conduct research on the pipes and identify areas of high-risk— those close to failure or with a short life expectancy. The project uses a floating robot equipped with a high-definition video camera, laser, and sonar to scan the water lines.

This has allowed the city to address these issues with a planned project instead of an emergency repair.

The outcomes of this collaboration have proven to be extraordinary, with a dramatic decrease in the frequency of main breaks, reduced sewer backups, increased customer convenience, and continuity of service. The use of this technology, which includes a floating robot, has enabled Arlington to productively allocate resources and human capital to infrastructure system upgrades and maintenance operations. For example, the city was planning to replace a water main in conjunction with a roadway project at a cost of $1 million. Using the pipe analysis technology for evaluation, it determined that it could instead replace the pipe joint at a cost of $4,000. The avoided costs were then reallocated to water mains in need of an urgent replacement.

In 2013, Arlington began the process of converting water meters to AMR technology under the Sensus Advanced Metering Infrastructure plan, enabling residents to monitor their own usage. This project led to more accurate registration and facilitation of revenue recovery. It is an in-house project that allows Arlington to start embracing technology, provides residents with information regularly, and adapts to constantly evolving technology. In 2016, Arlington Water Utilities was awarded a $300,000 WaterSMART federal grant to improve the city's leak-detection capabilities; reduce electricity consumption; and generate cost savings related to water treatment, pumping, and meter reading. This expedited the Advanced Metering Infrastructure plan as well. Accordingly, about 40,000 smart meters have been installed in the first two years of the ten-year project to replace 108,000 meters.

Arlington has financed these smart technologies and water infrastructure upgrades using multiple financing mechanisms, such as federal grants, the capital budget, water utility rates, project cost savings, and low-interest loans. The city is aggressively recapitalizing its water utility systems and continues to be a low-cost provider of water utilities. It maintains right of way for the sewer line with a warranty program and has saved up to $600,000 a year. In 2017, Arlington instituted a convenience fee for credit card usage, which made approximately $600,000 in operating expense available to invest in system upgrades for its utility customers. The Water Utilities Department has also been working with the Texas Water Development Board, which provides outreach and technical and financial assistance for responsible water development and water conservation in Texas. The city of Arlington's Water Utilities Department has also funded many of its investments in smart cities technologies through operating efficiencies. In 2017, the Texas Water Development Board (TWDB) approved by resolution financial assistance in the amount of a $11,445,000 loan, from the Drinking Water State Revolving Fund to the City of Arlington (Tarrant County) to financially assist water system improvements. For the period of 2016-17, TWDB approved by resolution financial assistance in the amount of $6,855,000, from the Clean Water State Revolving Fund to the City of Arlington (Tarrant County) to financially assist the construction of wastewater system improvements.

Challenges

Arlington has a very supportive senior management and council. That is due, in part, to the region's susceptibility to both extreme drought and floods, which means that applying technologies that reduce water main breaks, water leaks, and sewer overflow can have significant benefits for operating efficiency.

Water and wastewater utilities are also the most capital-intensive of all utilities, and Arlington's water utility is working to maintain its status as a low-cost provider of services. Infrastructure maintenance is very important to Arlington's operating efficiencies, as well as to providing high-quality service to utility customers. To meet these needs, Arlington avoids reliance on water rate and tax increases as much as possible.

Takeaways

Arlington's experience highlights the importance of leadership support for smart cities applications and making it part of the culture of how the city does business. The city's dedication to regular communication and engagement has empowered departments to focus more on how to apply these technologies in their work. The city believes that if money is spent well, it often pays back and if resource allocation is done well, great synergies occur.

Arlington's approach is focused on assessing the available resources, planning strategies comprehensively, and practicing good decision making with the help of data and technology. Deploying smart cities technologies has helped the city to effectively use data to prioritize investments while continuing to provide the services that people want and expect and avoid water rate and tax increases. “Good decision making can be adopted by cities, businesses, and municipal and state government in several ways. Arlington strongly believes in data-driven decision making, embracing technologies for effective resource allocation and that there is a return on investment if the capital is spent wisely,” said Buzz Pishkur, City of Arlington’s director of water utilities.

Interview Participant

Walter “Buzz” Pishkur
Director of Water Utilities, City of Arlington, Texas

Endnotes

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