



National Institute of  
**BUILDING SCIENCES**

**2016**

# **Moving Forward:** Findings and Recommendations from the Consultative Council



*An Authoritative Source of Innovative Solutions for the Built Environment*



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## Introduction

The design, construction, operation and regulation of buildings and infrastructure, while operating in the background of our daily lives, is the foundation of every aspect of the nation's economy—from commerce to education to housing. Buildings, infrastructure and the industry that supports them deliver significant benefits to the nation. They provide major contributions to the U.S. economy while protecting citizens and businesses from the potentially devastating impacts of both natural and man-made disasters.

The National Institute of Building Sciences Consultative Council brings together leading U.S. building industry organizations to identify the policies, practices and trends that hinder achieving the nation's goals of realizing high-performance buildings and communities. Each year, the Council develops a *Moving Forward Report* to examine some of these challenges and offer findings and recommendations on how to overcome them.

As identified in the 2014 and 2015 *Moving Forward Reports*, the availability of a skilled building-related workforce now and into the future remains a significant challenge to the U.S. building industry. While the issue of water also has been covered in prior reports, a recent increase in droughts and infrastructure issues in places such as Flint, Michigan, have underscored the importance of potable water and the efficient and healthy use of this limited resource. While many of the other challenges identified in earlier reports remain and the associated findings and recommendations are still relevant, the two issues of workforce and water continue to weigh heavily on the building industry, and are the primary focus of this 2016 *Moving Forward Report*.

## Developing a Skilled Workforce

To maintain its contributions to the U.S. economy and the health, safety, welfare and resilience of the nation's citizens, the building industry requires the availability of a skilled workforce.

Over the past several years, almost all sectors of the building industry have reported a growing shortage of skilled construction workers—in multiple building disciplines and trades, and across states and regions—with a dramatic shortage of workers in key industry trades. Surveys of the code official workforce and other building-related disciplines have revealed similar challenges.

Experienced workers are retiring, leaving or have left the industry, without a sufficient number of young people in the pipeline to replace them.

At the same time, many segments of the industry are struggling with the challenge of recruiting high school students who have guidance counselors, teachers and parents promoting a four-year college degree as a measure of success while discouraging training and careers in building trades. The members of the Consultative Council are deeply concerned about the availability of a future workforce that can meet the goals of our respective organizations and the goals of the communities we serve. Reversing this trend requires a coordinated and collaborative effort among government, educators and industry.

To facilitate resolution, the Consultative Council identified several causes of this disturbing trend and offers recommendations to address them.

### *A Narrow Definition of Success*

As the nation continues to venture deeper into the Information Age and competes on a global stage to demonstrate technological and economic prowess, the definition of success has prioritized earning a college degree. Many high school counselors—and parents as well—consider earning a college diploma as a crucial step in a young person’s development to adulthood, regardless of the content of the degree’s major or the high cost (and potential student loan amounts) associated with obtaining it.

However, not every young person is suited to attending a four-year college. While our nation’s education system focuses on supporting colleges and universities, there is little attention paid to offering similar support—financial or otherwise—for vocational and technical schools. Four-year colleges can offer extensive financial aid options to attract students. Where federal programs do support technical training, they often are designed primarily around poverty alleviation, reintegration or workforce placement, not as tools to encourage high school students or current workers seeking new opportunities. The education system’s neglect of vocational and technical careers and job pathways—livelihoods that add value, can be quite lucrative and create highly skilled workers essential to our economy—has contributed to a shortage of workers in these industries.

Vocational and technical schools should serve as a fertile training ground to bring new blood into the construction industry, but it needs to happen *before* the professionals who could serve as mentors retire. Typically, unless a family has a history in construction or related fields, parents and high school guidance counselors usually encourage students to go to college, because that is the strong cultural message—and only recommend considering attending a technical training program if they lack financial means or are a mediocre student.

In perpetuating this message without highlighting the importance of skills and trades to the economy, the nation is losing a generation of new, highly skilled tradespeople and technicians. Students with the aptitude and desire to enter the building industry are being directed to degrees that just may not fit them—like trying to pound a square peg into a round hole—either for ego or to achieve a certain college-access rate for a high school’s reputation.

### *Providing Access and Encouragement*

When high schools face financial challenges, they often consider dropping vocational education options, even as electives, which perpetuates the lack of access and exposure. Yet, young people who get a “taste” of working with their hands through vocational or technical degree programs can find an unexpected, fruitful and very exciting career path opening up for them. High schools should also offer aptitude tests as another way to mine latent skills in the trades.

Meanwhile, many students who would excel in vocational and technical degree programs, but otherwise attend four year colleges, are riddled with significant debt and ultimately find themselves in unsatisfying jobs not tied to their degree.

Clearly, the industry has a lot of work to do, but government and educators must join the effort. The current way of thinking must change—not to minimize the value of a four-year degree, but rather to offer other options better-suited to some students—options that also will help to not only maintain, but continually improve the built environment.

The messaging and outreach to the public must evolve. Parents, students, educators, guidance counselors and policy makers should understand that vocational and training schools are for those who have a special aptitude—some of whom may thrive within a regular school environment and some who may not because that environment is disconnected from their aptitude.

Outreach, engagement and encouragement must expand beyond those pursuing careers for the first time to include returning veterans. Many veterans have obtained highly desirable skills during their service that would be valuable to the building industry. Veterans should also be provided with information, support and training to enter rewarding careers within the building industry as they transition into civilian life.

A number of jobs in construction and building safety increasingly rely on technology and the core curriculum, such as math, science and composition; they are not just “hard labor.” New tools within the industry, including building information modeling (BIM), virtual and augmented reality and the use of drones, offer exciting opportunities requiring specialized knowledge. These are important jobs that contribute to communities and the nation. Additionally, they are careers and jobs that cannot be sent offshore—the U.S. building industry requires workers be in the United States to undertake them.

There is a perception that the government does not need to be involved in encouraging workers to enter these professions because trade unions and merit-shop-based training programs are fulfilling the need for trained construction professionals. While the network of apprenticeship and trade training programs provides highly skilled workers, there are not nearly enough young people entering these programs. Community college-based training programs struggle to find students. Further, most construction workers today—86.3 percent—are not unionized.<sup>1</sup> These factors contribute to a lack of clear direction on where interested workers can go for training. Programs that pair vocational students with mentors in the field are few and far between, in part, because too few people see the critical need for funding and supporting such programs.

In general, careers in the construction industry are not seen as “exciting” jobs. There are few, if any, television dramas currently about construction or building officials. Perhaps there would be if people (and screenwriters) more widely understood the role building officials play in protecting buildings from natural disasters or how building professionals utilize technology to construct high-performance buildings.

Government, education providers and the private sector must undertake a concerted effort to develop programs that highlight the benefits of attending vocational and technical training, and explain how training can lead to a career that, while often unheralded, provides great value to society by keeping the nation safe and building the infrastructure on which our businesses and citizens rely.

The nation cannot afford to wait any longer to change perceptions of vocational and technical schools. Failure to move quickly will result in a continued loss of skilled workers and potentially undo the decades of work spent improving construction techniques and building safety, as on-the-ground expertise and technical knowledge dissipates when the current workforce retires.

### *Roles for Government and Private Industry*

Government at all levels should do more to encourage trade apprenticeships, internships and on-the-job training. The District of Columbia Department of Consumer and Regulatory Affairs, for example, offers apprenticeships for high school students. Other jurisdictions should as well.

Just as they do for college tuition, federal student loan programs should provide equal access for students wishing to enter technical education programs. Efforts to reauthorize the Carl D. Perkins Career and Technical Education Act are underway. The reauthorization includes provisions to specifically support the role of local educational institutions—high schools and

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<sup>1</sup> Bureau of Labor Statistics, Economic News Release: Union Members Survey, January 28, 2016. <http://www.bls.gov/news.release/union2.nr0.htm>.

community colleges—in preparing the workforce needed to keep businesses growing and contributing to the economy.

Government and the private sector also need to improve coordination. Government and the construction industry must work collaboratively to help change the culture and draw more people into technical and vocational programs. They must show there is a need for highly skilled construction and building officials, and demonstrate their concern and urgency by providing scholarships and other financial support.

Private industry also needs to work with schools to establish technical and vocational programs that issue certifications that are valued by employers. These programs must be seen as worth participants' time and money, making them more highly skilled and highly valued workers. In turn, the government should encourage the creation of industry-recognized certifications and designate their use under federal job-training and career and technical education programs.

Through leading-edge vocational and technical schools, students can gain a well-rounded education, including general skills (e.g. writing and math), as well as career-specific trade skills.

### *Engaging Women*

Any outreach efforts should focus specific attention on letting young women know about the career opportunities in construction, design, operations, safety and assessments, and how their abilities can contribute to the economy. While the number of women in the sector has increased over the past two decades, the industry has done very little to break down traditional barriers or to address the challenges women face when entering an industry historically dominated by men.

The industry's image of being male-dominated hurts the ability of trades to recruit women into many of the fields with the highest demand for workers. The industry needs training programs and recruitment efforts directly targeted at women to increase their participation. Industries who have made a concentrated effort to recruit women often find that women are eager to take on a role in a job where they have opportunities for professional growth and can act as role models and mentors for other women. Those who have support from their employers and co-workers can achieve respect in their communities and in the national arena. Such support for women in the field must be fostered.

For example, the Women's Bureau of the U.S. Department of Labor reports that, in 2010, there were roughly 526,000 pipe layers, plumbers, pipe fitters and steam fitters, of which an estimated 7,900 (1.5 percent) were women. A number of organizations, such as Chicago Women in Trades, Oregon Tradeswomen and the Washington state-based Sisters in the Building Trades provide local support systems for those who have selected a career in such

traditionally male-dominated fields. More of these kinds of groups are needed for women, and for everyone who seeks to work in construction and/or code compliance.

### *Student Debt*

Students interested in building industry fields such as architecture and engineering, which do require post-secondary education, face a different challenge: the rising burden of student debt. As the cost of education continues to increase, many graduates of programs in these fields are choosing to leave the building industry because of their high debt loads rather than follow the path to professional licensure.

Government programs have enabled graduates in the medical, legal and veterinary professions to apply their skills in underserved areas in exchange for debt relief or repayment of their student loan balances. Similar partnerships between governments and public-interest design organizations could improve community outcomes and provide valuable experience for building industry professionals in exchange for debt relief.

### *Upgrading the Current Workforce*

Technology is changing faster than any time in history. Inventors of innovative technologies and design strategies are racing to meet today's challenges and the goals identified by society and policy makers. At the same time that the nation needs to assure the future workforce is prepared to deliver and maintain high-performance buildings and infrastructure that meet current and future goals, it also is imperative that members of the existing workforce continually upgrade their knowledge and skills.

The current and future workforce must have the knowledge and training necessary to effectively utilize the tools, technologies and practices that support increasingly higher levels of performance. Contractors must install and deploy new technologies correctly to realize their intended benefits. Competent building inspectors help prevent sub-standard installation of cutting-edge technologies and effective enforcement spurs industry interest in seeking technician competency. Building operators must have the knowledge to effectively utilize building features to meet the design intent. When appraisers recognize the value of buildings that use new technologies, safety and sustainability practices, they create an immediate incentive for other building owners to also pursue these advances.

Building construction, maintenance and operation are no longer just jobs, they are professions. These professions have become lifetime commitments rather than migratory employment. Not unlike other professions, they require professional development and continuing education.



## *Recommendations for Advancing a Skilled Workforce*

To ensure a future workforce will be available to support a high-performance built environment, the Consultative Council offers the following recommendations:

- Congress, the U.S. Department of Education (DoEd), state and local governments, schools and industry stakeholders should promote technical and trade programs in K-12 and technical schools, emphasizing good career opportunities, not a societal judgment. This is applicable to ALL students—all genders, all races, all economic backgrounds—to break down preconceived notions of who can *choose* to go into technical building careers.
- Industry stakeholders, educators, the U.S. Department of Labor (DOL) and state and local governments should support programs and training that encourage women to enter the construction sector.
- The U.S. Department of Defense, U.S. Department of Veterans Affairs (VA), labor unions, technical education providers, industry trade groups and veterans groups should provide returning veterans with information, support and training to enter rewarding careers within the building industry as they transition into civilian life.
- The DoEd, DOE, EPA, DOL and other relevant federal agencies should work with the private sector to create a public service announcement campaign highlighting the importance of the building industry to the economy, the many exciting opportunities available in the industry and potential educational pathways to entering the industry.
- Congress and the DoEd should create opportunities for building industry professionals to apply their skills in underserved communities in exchange for reductions in student debt.
- Congress and the DoEd should encourage states to develop regional and, wherever possible, national reciprocity programs for certified trade professionals. Careers that allow for geographic mobility are more attractive to students and young people investigating career options.
- Congress, through the DoEd and DOL, should support research aimed at quantifying the benefit of a trained building workforce in order to facilitate wide-spread certification and ongoing training and to allow capture of the benefits in legislation and budgetary actions.
- Federal agencies with building-related responsibilities, including the U.S General Services Administration, DOE, DOD and VA, should recognize the necessity and value of having certified trade professionals by incorporating certification requirements into procurement and contracting processes. This is a natural extension of the necessity and value of having safety and building requirements in the first place. The federal government has shown it values using updated codes for resilience in the face of

disasters. It is equally important to have qualified contractors, tradespeople, building officials and other disciplines to implement them.

- The DoEd should promote industry credentials/certifications as a viable use of federal money, such as through the Federal Perkins Loan Program (formerly known as the National Defense Student Loans), National Direct Student Loan and Perkins Loan Program, which provide low-interest loans to help needy students finance the costs of post-secondary education, and allow the use of such funds to support maintenance of those credentials through continuing education courses.
- Congress and GSA should require the certification and ongoing education and training of building-level federal employees and contractors who work in federal facilities by accelerating the implementation of the Federal Buildings Personnel Training Act across federal agencies and development of criteria for contractors.

## Water Resources and the Built Environment

Regardless of how well the nation's homes and commercial buildings are designed and constructed, how sustainable and energy-efficient they are or how vital they are to a community or to a local economy, all buildings require a connection to a safe, reliable and continuous water supply in order to fulfill their purpose. When a building does not have a safe and secure water supply, normal building functions stop, the conducting of commerce ends, people are displaced and jobs are lost.

The most-recent federal government survey documents that 40 of the 50 states will experience water shortages by 2024.<sup>2</sup> The epic drought in California and elsewhere in the arid West continues for the fourth year; though the 2016 El Nino was anticipated to provide short-term relief there, it fell short of expectations. The Southeast also experienced a serious drought in 2016. Water scarcity is expected to cost the nation billions of dollars in lost commerce.<sup>3</sup> Yet, the nation's distribution systems are failing due to decades of neglect, and treated drinking water—drinking water that required significant energy in its treatment, pumping and distribution—is increasingly leaking out before it gets to its destination. Likewise, aging wastewater systems are leaking and increasingly susceptible to failure and flooding due to strong storms, which pollute bays, rivers and lakes.

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<sup>2</sup> U.S. Government Accountability Office, *Freshwater: Supply Concerns Continue, and Uncertainties Complicate Planning*, May 22, 2014. <http://www.gao.gov/products/GAO-14-430>

<sup>3</sup>The impact of drought on State of California agriculture alone was \$2.7 billion in 2015. Source: University of California-Davis, *Economic Analysis of the 2015 Drought for California Agriculture*, 2015. [https://watershed.ucdavis.edu/files/biblio/Final\\_Drought%20Report\\_08182015\\_Full\\_Report\\_WithAppendices.pdf](https://watershed.ucdavis.edu/files/biblio/Final_Drought%20Report_08182015_Full_Report_WithAppendices.pdf)

In Flint, Michigan, the nation witnessed a tragic and cautionary example that showed how a community can be impacted when water safety is compromised through mismanagement, poor oversight and short-sighted cost avoidance decision-making. The occurrences of lead poisoning and legionellosis outbreaks among vulnerable populations in Flint epitomize the unintended consequences that require study in order to develop and implement best practices and guidance.

Understanding how water will be used in the United States and globally in the future also requires development of a new paradigm. A new, holistic approach to the water-use cycle must consider the sources, treatment, distribution, use and reuse of water and the better utilization of wastewater and stormwater as important resources in the water-energy nexus. Only by establishing a strategic approach recognizing the limited, interconnected supply of water can society continue to advance in the face of the daunting reality of the long-term needs for an essential, finite resource while simultaneously allowing for population growth.

The Consultative Council offers this report to help policy makers foster smarter public and private-sector investments that will provide long-term, sustainable solutions. How water will be used in this century and beyond must be vastly different from how water was used in the 20<sup>th</sup> century. New technologies, better materials and systems, smarter processes and new ideas should all be part of the solutions and can provide great opportunities for American businesses and workers. The national discussion on how to most effectively address complex water problems must start now.

### *Water Distribution*

In 2013, the American Society of Civil Engineers (ASCE) gave the nation's drinking water and wastewater systems both a grade of "D" (poor) in its *Report on America's Infrastructure*, estimating an astonishing 240,000 water main breaks per year and citing the urgent need to invest in the nation's drinking water and wastewater infrastructure.<sup>4</sup> Approximately 6 billion gallons of treated water are lost each day (over 2 trillion gallons/year) due to leaking from aging and poorly managed distribution systems.<sup>5</sup> The American Water Works Association's *2016 State of the Water Industry Report* cites the poor condition of water and wastewater infrastructure, financing for capital improvements and the lack of public appreciation for the value of water systems and services as their members' top three concerns.<sup>6</sup> These issues are complex and require leadership from all levels of government to ensure that Americans can continue to rely on the safe use of water in buildings across the nation.

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<sup>4</sup> American Society of Civil Engineers, *2013 Report Card for America's Infrastructure*

<sup>5</sup> Center for Neighborhood Technology, *The Case for Fixing the Leaks: Protecting people and saving water while supporting economic growth in the Great Lakes region*, 2013.

<sup>6</sup> American Water Works Association, *2016 State of the Water Industry Report*.

The United States has nearly 170,000 drinking water distribution systems, which complicates the ability to address these infrastructure challenges. Of these systems, approximately 54,000 are community-based systems that collectively serve over 264 million Americans. The remaining 114,000 are non-community water systems, each serving fewer than 500 people.<sup>7</sup> While there are far fewer public wastewater systems (approximately 14,780 wastewater treatment facilities and 19,739 wastewater pipe systems), the condition of many of these systems also is poor, with aging pipes and inadequate capacity that is causing the discharge of an estimated 900 billion gallons of untreated sewage each year.

In 2007, the U.S. Environmental Protection Agency (EPA) estimated that drinking water systems need a capital investment of \$335 billion. To address the nation's wastewater system needs over the next 20 years, including sewage collection and treatment infrastructure, will require investments totaling more than \$300 billion according to the Congressional Budget Office, EPA and other groups. Not surprisingly, continuing to neglect these problems makes them exponentially more expensive to resolve. The cost of inaction includes a high human toll: drinking contaminated water delivered from increasingly porous infrastructure could result in lost productivity, illness and even death.

Water utilities are under additional financial strain as they strive to meet EPA's Safe Drinking Water Act (SDWA) and Clean Water Act (CWA) requirements. An ever-growing list of contaminants to report on, test for, monitor and eliminate from drinking water adds cost and limits the availability of funds for infrastructure projects. Yet, congressional appropriations for water projects have actually declined from 2008 to 2012, averaging \$1.38 billion annually or \$27.6 billion over 20 years—a mere 8% of EPA's estimated required investment needs.<sup>8</sup>

The mechanism for channeling water-related federal funding has historically been through state revolving loan funds (SRFs) created for both the SDWA and CWA, with federal funding appropriated by Congress annually. These funds are not subsidies or grants as they are in the energy sector, but rather low-interest loans, which are paid back by the utility system over time. Unfortunately, the annual appropriations for these loans have been steadily declining. Local water utility ratepayers currently bear the costs of investments through significantly

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<sup>7</sup> Non-community public water systems are facilities, such as schools, factories, restaurants, resorts and churches, served by their own water supply (usually a well). See Illinois Department of Public Health, "Non-Community Public Water Systems." <http://www.dph.illinois.gov/topics-services/environmental-health-protection/non-community-public-water-systems>

<sup>8</sup> American Society of Civil Engineers, *2013 Report Card for America's Infrastructure*.

increased water and wastewater rates. Rates are climbing at a faster rate than other utilities, such as energy and telecommunications, and clearly faster than the consumer price index.<sup>9</sup>

EPA's efforts to provide creative funding mechanisms for utilities through SDWA and CWA SRF programs; the Water Infrastructure Finance and Innovation Act; and the Water Infrastructure and Resiliency Finance Center are laudable, but it is clear that these programs need to be expanded. The federal government must increase funding through the expansion of existing financing programs to help utilities improve infrastructure while also meeting federally mandated water quality requirements.

The case of Flint illustrates the struggles associated with rising costs in economically disadvantaged communities. It also highlights the need for water purveyors to carefully consider money-saving decisions that might compromise drinking water quality. Switching water sources, changing chemical disinfectant or the simple act of replacing old and leaky utility pipes and water supplies to buildings can disrupt the entire distribution system and negatively impact water quality. Drinking water can become more corrosive as a result of changes to disinfectant chemicals. As a result, the protective coatings that have developed over time can dissolve, exposing old metal surfaces, which can result in dangerous spikes in lead levels. EPA, in consultation with industry experts, should develop a set of best practices to provide utilities with the necessary precautions and preemptive steps they need to take prior to making such changes.

Due to severe and growing water scarcity, especially in the Western United States, communities need to become increasingly efficient with the use of treated drinking water. Considering the forecasted population growth in California<sup>10</sup> and elsewhere in the arid West, the need is clear to do more with less water. Current water-efficiency measures must stay in place. At the same time, in addition to retrofitting residential and commercial buildings with the most-efficient plumbing fixtures and appliances available, governments should enact policies to incentivize behavioral changes that will reduce water waste and reward water-neutral new development.<sup>11</sup> Smart pricing can be an effective tool to reduce water waste, particularly in outdoor landscape irrigation. Research has shown that the price of water can strongly influence how water is used in both residential and non-residential applications. As water rates skyrocket to cover needed infrastructure investment, the higher water prices will certainly impact water use.<sup>12</sup> The

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<sup>9</sup> Michigan State University, *Trends in Consumer Prices (CPI) for Utilities through 2013*.

[http://ipu.msu.edu/research/pdfs/IPU%20Consumer%20Price%20Index%20for%20Utilities%202013%20\(2014\).pdf](http://ipu.msu.edu/research/pdfs/IPU%20Consumer%20Price%20Index%20for%20Utilities%202013%20(2014).pdf)

<sup>10</sup> California's population is forecasted to increase 41% to 52.6 million people by 2060. U.S. Census Bureau, 2010

<sup>11</sup> Alliance for Water Efficiency, *Water Offset Policies for Water Neutral Community Growth*, January 27, 2015.

<http://www.allianceforwaterefficiency.org/net-blue.aspx>

<sup>12</sup> University of California, Riverside, "Do Increasing Block Rate Water Budgets Reduce Residential Water Demand? A Case Study in Southern California," 2013.

Consultative Council encourages EPA to continue its research on the economic impacts that higher water rates have on lower-income populations to ensure that financially vulnerable households are not disproportionately affected.

The challenge is that increasing the efficiency of water systems that were designed to support much higher use levels can have unintended and potentially dangerous consequences. As community water usage becomes more efficient, the length of time water spends in the distribution system increases—especially to buildings furthest from the point of treatment. As a result, water may reach many buildings with little to no residual disinfectant. This provides opportunity for legionella and other opportunistic pathogens to thrive in premise plumbing systems. Per the National Research Council, premise plumbing refers to the piping within a building or home that distributes water to the point of use.<sup>13</sup> The Center for Disease Control and Prevention (CDC) estimates that there are between 8,000 and 18,000 annual cases of legionellosis, most resulting from use of water in premise plumbing systems.

The CDC recently issued official guidance to building managers to help prevent the spread of legionella in commercial buildings.<sup>14</sup> While industry and public-sector experts have developed new standards and guidelines to help mitigate future outbreaks<sup>15</sup>, the nation lacks a clear regulatory path that requires the new standards be implemented. No single regulatory authority has jurisdiction over all of the systems and building-based operations that need to be put into place. Thus, mandating the use of these standards through legislative measures needs to be considered. Further, the required use of disinfectant injection pumps should be considered in areas that serve remote portions of municipal water systems to ensure the water supplied to buildings in those areas have sufficient residual disinfectant to mitigate the growth of opportunistic pathogens in plumbing systems. At a minimum, the SDWA should be revised to allow for the onsite treatment of water in buildings that contain at-risk populations—such as hospitals and elder care facilities—without overly burdensome water quality reporting requirements.

Finally, to ensure the delivery of safe water to newly constructed buildings in urban areas, it may not make sense to expand existing large, oversized water distribution systems at a time when per-capita water use is declining. Water providers should consider developing and constructing smaller, community-based, urban water and wastewater systems that serve

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<sup>13</sup> National Research Council, “Drinking Water Distribution Systems: Assessing and Reducing Risks,” 2006. <https://www.nap.edu/catalog/11728/drinking-water-distribution-systems-assessing-and-reducing-risks>

<sup>14</sup> Centers for Disease Control and Prevention, “Developing a Water Management Program to Reduce *Legionella* Growth and Spread in Buildings: A Practical Guide to Implementing Industry Standards,” 2016. <http://www.cdc.gov/legionella/maintenance/wmp-toolkit.html>

<sup>15</sup> See ASHRAE Standard 188 – 2015, Legionellosis: Risk Management for Building Water Systems

smaller geographical areas and fewer people. The residential and commercial buildings in the service areas of such systems can be designed from the onset to be highly water-efficient and able to utilize alternate water sources safely and effectively. Likewise, smaller, community-based, decentralized wastewater systems can be developed to take advantage of solid waste materials that can be put to beneficial use.

### *Wastewater*

Wastewater and sewer systems utilize water and gravity to convey solid wastes from buildings to wastewater treatment facilities. As buildings use less water, the risk increases that blockages will occur in building drains and sewers. There have been anecdotal reports of increased blockages in building drains; however, to date these problems seem to be relatively rare.

A more commonly reported problem is an increased frequency of sewer blockages and corrosion failures in sewer pipes due to more concentrated and acidic effluent, a direct result of using less water in buildings. A popular misconception is that increases in sewer blockages are a direct result of so-called “low-flow” toilets, which use less than half of the water used by water-guzzling models dating back to the mid-1990s and earlier. However, as detailed in Table 1, flow rates and consumption values for all plumbing fixtures, fixture fittings and water-using appliances have decreased significantly. Further, commercial and industrial equipment of all types are increasingly becoming more water-efficient. This overall reduction in water usage is contributing to the increased incidences of blockages and corrosion-related failures in sewer systems. Here again, EPA, the National Institute of Standards and Technology (NIST), wastewater treatment facilities and industry need to determine and share best practices detailing the steps utilities can take to mitigate these failures and maintain their systems as efficiently and cost-effectively as possible. Additionally, studies need to be conducted to identify the best materials to utilize for new sanitary systems and for rehabilitating existing failed sewer lines.

### *Premise Plumbing*

Since 1999, Americans have reduced their indoor household water use by 22% on average and per capita water use by 15%.<sup>17</sup> These efficiency gains can be attributed to the continuing impacts of the Energy Policy Act of 1992, which regulated the consumption and flow rates of many plumbing products; to utility incentive programs, which target the installation of water-efficiency products; and to the creation of EPA’s WaterSense voluntary labeling program in 2006.

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<sup>17</sup> Water Research Foundation, *Residential End Uses of Water*, 2016.

**Table 1: Water consumption by water-using plumbing products and appliances** <sup>18</sup>

Water-Using Fixture or Appliance	1980s Water Use	1990 Requirement	EPAct 1992 Requirement	2009 Baseline Plumbing Code	2015 “Green Code” Requirements	Reduction in Avg Water Use since 1980s
Residential Bathroom Lavatory Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	2.2 gpm	1.5 gpm	<b>57%</b>
Showerhead	3.5+ gpm	3.5 gpm	2.5 gpm	2.5 gpm	2.0 gpm	<b>43%</b>
Toilet – Residential	5.0+ gpf	3.5 gpf	1.6 gpf	1.6 gpf	1.28 gpf	<b>74%</b>
Toilet – Commercial	5.0+ gpf	3.5 gpf	1.6 gpf	1.6 gpm	1.6 gpm	<b>68%</b>
Urinal	1.5 to 3.0+ gpf	1.5 to 3.0 gpf	1.0 gpf	1.0 gpf	0.5 gpf	<b>67%</b>
Commercial Lavatory Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	0.5 gpm	0.5 gpm	<b>86%</b>
Food Service Pre-Rinse Spray Valve	5.0+ gpm	No requirement	1.6 gpm (EPAct 2005)	No requirement	1.3 gpm	<b>74%</b>
Residential Clothes Washer	51 gallons/load	No requirement	26 gallons/load (2012 standard)	No requirement	16 gallons/load	<b>67%</b>
Residential Dishwasher	14 gallons/cycle	No requirement	6.5 gallons/cycle (2012 standard)	No requirement	5.0 gallons/cycle (ASHRAE S191P)	<b>64%</b>
gpm: gallons per minute gpf: gallons per flush						

Maximizing indoor water efficiency through regulatory means is approaching the practical limits. Experts are concerned that further reductions in indoor plumbing consumption values and flow rates would deteriorate water quality in premise plumbing systems while providing minimal water conservation returns. The Plumbing Efficiency Research Coalition (PERC), an ad-hoc coalition of private-sector associations interested in plumbing and water efficiency,<sup>19</sup> completed research in 2015 to investigate the lower limits of toilet consumption values necessary to effectively keep building drains clear and free from chronic blockages. The study concluded that toilets consuming 1.28 gallons (4.8 liters) per flush (gpf)—currently referred to as high-efficiency toilets—provide for adequate drainline transport, even in very-long commercial building drains where little to no water from other sources is available to contribute to the transport of solid wastes. However, the study also found that reducing toilet consumption further in such buildings would significantly increase the risk of chronic blockages.

<sup>18</sup> Alliance for Water Efficiency: [http://www.a4we.org/uploadedFiles/US-Water-Product-Standards-Matrix\\_2016-11-07.pdf](http://www.a4we.org/uploadedFiles/US-Water-Product-Standards-Matrix_2016-11-07.pdf) and [http://www.a4we.org/uploadedFiles/Indoor-Water-Efficiency-Stds-Codes-Guidelines\\_2016-11-07.pdf](http://www.a4we.org/uploadedFiles/Indoor-Water-Efficiency-Stds-Codes-Guidelines_2016-11-07.pdf)

<sup>19</sup> PERC consists of the Alliance for Water Efficiency (AWE), the American Society of Plumbing Engineers (ASPE), the International Association of Plumbing and Mechanical Officials (IAPMO), the International Code Council (ICC), the Plumbing-Heating-Cooling Contractors – National Association (PHCC) and Plumbing Manufacturers International (PMI)



While many water experts discourage additional regulatory actions to further reduce consumption and flow rates on water-consuming plumbing fixtures and appliances, U.S. residential and commercial buildings can still increase their efficiency. Research commissioned by Plumbing Manufacturers International (PMI) in 2015<sup>20</sup> indicates that only 7% of the toilets installed in the United States are high-efficiency toilets. Incentive programs that promote removing obsolete water-guzzling products from residential and commercial buildings and replacing them with plumbing products and appliances recognized by EPA's WaterSense program continue to have great potential and will deliver significant water efficiency. Additional incentive programs for the installation of smart metering and leak detection technologies will make buildings more efficient without impacting the efficacy or safety of the water supply or sanitary systems.

One important area where federal government leadership is essential is the proper sizing of water pipes in buildings. Pipe-sizing calculations are complex and need to take into account the potential for the simultaneous use of all water-consuming fixtures, appliances and equipment within the building, while still providing important residual pressure. Over-sized systems result in low water quality because of slower flows, and thus increase the potential for opportunistic pathogens to thrive in water pipes. Under-sized systems are disruptively noisy, can generate destructive water hammer shock<sup>21</sup> due to excessively high flow velocities, increase the potential for hot-water scalding incidents occurring from pressure changes in the plumbing system and can cause the system to fail prematurely due to leakage and erosion corrosion. While the problem is complex, right-sized plumbing can improve water quality and increase water and energy efficiency for the life of the building without adding cost.<sup>22</sup>

Dr. Roy Hunter developed the current water supply pipe-sizing methods at the National Bureau of Standards (now NIST) in the 1930s and 40s. The nation's plumbing codes have used these methods ever since. While the industry slightly revised the calculations over the years, they remain grossly outdated and do not reflect current water use. The private sector initiated research to address this issue for residential buildings<sup>23</sup> by utilizing a database on residential water use originally collected for a different research project. However, a similar project on

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<sup>20</sup> Plumbing Manufacturers International, US Market Penetration Of WaterSense Shower Heads, Lavatory Faucets And Toilets, July 2015

<sup>21</sup> Water hammer is the sudden impact of a mass of fast-moving water on a piping component such as a valve or an elbow. See Otakar Jonas and Joyce M. Mancini, "Water hammer and other hydraulic phenomena," Power Magazine, March 15, 2007. <http://www.powermag.com/water-hammer-and-other-hydraulic-phenomena/>

<sup>22</sup> Currently, plumbing systems are considerably oversized. Right-sized plumbing systems will utilize smaller diameter pipes, thereby actually reducing construction costs marginally.

<sup>23</sup> The American Society of Plumbing Engineers (ASPE), the International Association of Plumbing and Mechanical Officials (IAPMO) and the Water Quality Research Foundation (WQRF) have developed an updated pipe-sizing calculation method, which is currently under review at the model plumbing code level.

non-residential buildings cannot be initiated until research is conducted and a database developed to detail how non-residential buildings use water. The federal government should initiate new research programs to better understand how non-residential buildings use water and to lead the work required to develop and apply a modern pipe-sizing method.

It should be noted that EPA's WaterSense program passed two very-significant milestones in 2016. First, 2016 marked the 10-year anniversary of WaterSense. More significantly, in its first 10 years, the program saved over 1.5 trillion gallons of water [equivalent to 2,271 Olympic-sized swimming pools], saved Americans more than \$32.6 billion in water and energy bills, avoided the use of 212 billion kilowatt-hours of electricity and prevented 78 million metric tons of carbon dioxide emissions.<sup>24</sup> Based on its effectiveness in making the nation more water-efficient, Congress should increase funding for the WaterSense program, which currently is funded at under \$2 million annually at the discretion of the EPA Administrator. (By comparison, the EnergyStar program is funded at over \$40 million annually.) Without formal authorization by Congress, the WaterSense program is unlikely to see increased funding and risks being eliminated.

While regulatory action on indoor water use would achieve only slight gains in water efficiency, outdoor water use provides an opportunity for more substantial and safe efficiency. Outdoor water use varies greatly by region, but can account for up to 70% of residential water use in arid areas of the country where efficiency is most needed. The construction codes and standards currently available provide comprehensive water-efficiency provisions for outdoor uses of water. The federal government should consider offering incentives to states and local jurisdictions to adopt and enforce progressive water-efficiency codes and standards.

### *Water Reuse*

One possibility that has great potential to reduce potable water use is the reuse of graywater and rainwater. However, water reuse must be carefully considered and adequately regulated to ensure that water reuse systems are installed and maintained properly and that the water is adequately treated for its intended use.

Communities across the United States are already reusing water in very diverse ways. Americans are increasingly utilizing approaches, from the installation of rain barrels to utility-supplied recycled (also referred to as "reclaimed") water systems. Home and building owners are installing non-utility owned passive water reuse systems to divert rainwater and/or graywater from sanitary and storm sewers and to use it for beneficial applications, typically for landscape irrigation. Some Americans also are treating water for such uses as flushing toilets and in clothes washers. Codes and standards developers have been actively working to provide

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<sup>24</sup> U.S. Environmental Protection Agency WaterSense – 2016

codified installation and water-quality provisions to help ensure safe installation and use of such systems, including incorporation of backflow protection devices to ensure potable water systems are not contaminated with potentially dangerous non-potable water. However, EPA needs to provide specific, uniform water treatment and water-quality requirements for the uses of non-potable water in buildings.

Water-progressive communities in the Western United States are leading the way in the safe reuse of water in urban communities. For example:

- San Francisco passed the Non-potable Water Program ordinance in 2015, which mandates that all new buildings over 250,000 square feet have dual plumbing systems installed to accommodate the use of non-potable water, even if non-potable water is not yet available at the location. The San Francisco Public Utilities Commission treats water from alternate water sources, including rainwater, stormwater, graywater, nuisance ground water and even blackwater (water used in toilets, kitchen sinks and utility sinks) and then pipes the treated water to the separate non-potable water plumbing systems for beneficial use in and around buildings.
- The City of Austin's Reclaimed Water Program requires new commercial developments or redevelopments within 250 feet of a reclaimed water main to connect to it for irrigation, cooling and other significant non-potable water uses.

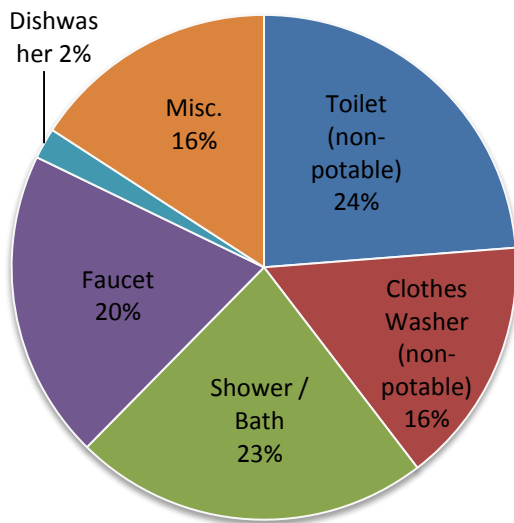
However, research still needs to be conducted to define best practices for dual-plumbing systems in buildings. For example, rather than installing a second system for the non-potable reclaimed water, it may be more cost-effective and ultimately safer to install a secondary system that utilizes smaller pipe diameters for the eventual use of potable water, leaving the older, original system available for non-potable uses of water.

Up to 40% of residential water use and up to 90% of non-residential building water use is consumed for non-potable applications (See Figures 1 and 2). Thus there is great potential to significantly reduce the use of expensive, energy-laden potable water by taking advantage of the many sources of non-potable water.

Technology will play an increasing role in addressing global water problems. There already are prototype residential and commercial buildings currently in operation that are zero or near zero-energy, water and waste buildings. They hold great promise in providing a blueprint on how to achieve extremely high levels of water efficiency safely and reliably. To reach zero-water use, the building first must be designed to be as efficient as possible, taking advantage of new, high-efficiency plumbing products, appliances and irrigation equipment. Green building certification programs through third-party certification have helped to promote integrated

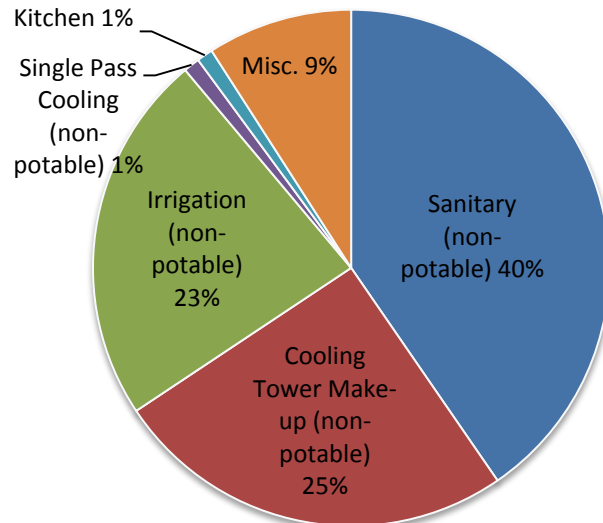
design processes and the incorporation of water safety and efficiency technologies and practices.<sup>25</sup>

**Figure 1: 40% of Demands are Non-Potable in Residential Buildings**



Source: Residential End Uses of Water – Version 2, 2016

**Figure 2: Up to 90% of Demands are Non-Potable in Non-Residential Buildings**



Source: EPA, Guidelines for Water Reuse, 2012

Early results are promising, and the lessons learned from these residential and commercial buildings will help pave the way for a more-efficient water future. The federal government should follow the development of these systems, support further needed research and consider incentives to bring emerging technologies to market.

### *Recommendations for Water Safety and Efficiency*

Addressing all of these challenges requires development of a strategic path forward that holistically considers how water will be used safely and efficiently. The recommendations the Consultative Council offers here are intended to initiate the dialogue and provide a starting point for such a strategy.

#### **Water and Wastewater Infrastructure:**

- Congress and EPA should expand and adequately fund SDWA and CWA SRF; the Water Infrastructure Finance and Innovation Act; and the Water Infrastructure and Resiliency Finance Center programs to help utilities improve infrastructure while also meeting federally mandated water quality requirements.

<sup>25</sup> Third-party certification creates accountability and is incentivized by federal, state, local and private entities to help realize financial, operational and other long-term benefits. National green building programs, such as the Green Building Initiative’s Green Globes®, International Code Council’s National Green Building Standard® and U.S. Green Building Council’s LEED® programs, are examples of certification programs that encourage consideration of water safety and efficiency issues early in the design process.

- The federal government should work with state and municipal governments in a bipartisan effort to begin a dialogue with the American public about the state of water infrastructure. This dialogue should be forthright and factual so that the public is made aware of the severity of problems and the financial investments necessary to address them.
- Federal and state government should expand the Clean Water and Drinking Water State Revolving Funds (SRFs) program to allow funding of specific projects that address water reuse. EPA should make additional funding sources available to assist utilities in meeting future treatment requirements that arise from the Safe Drinking Water Act and the Clean Water Act.
- The U.S. Department of Housing and Urban Development (HUD), through the Community Development Block Grant Program (CDBG), should expand its criteria and work with local officials to encourage applicants to apply for water-related upgrades and installations.
- EPA should consider requiring the use of disinfectant injector pumps to treat water delivered to buildings located furthest away from centralized water treatment facilities.
- Congress should revise the Safe Drinking Water Act to allow the treatment of water in buildings housing at-risk populations without triggering burdensome reporting requirements.
- EPA, in consultation with local governments and utilities, should conduct cost studies to determine the financial and environmental costs and benefits of smaller, decentralized urban water and wastewater systems.
- Congress and EPA should support research to develop a set of best practices for utilities pertaining to changes in water treatment sources and processes and to the repair and replacement of water distribution pipes; best practices for wastewater utilities to effectively mitigate sewer blockages; and identification of the best materials for new and rehabilitated sewer lines.

### **Premise Plumbing**

- Congress should authorize and increase funding for EPA's WaterSense program.
- NIST should reconstitute its research surrounding premise plumbing in order to modernize water pipe-sizing calculations for non-residential buildings and update existing requirements, which were developed in the 1930s and 1940s.
- All levels of government should offer more financial incentives to promote the removal of old water-guzzling plumbing fixtures and appliances and the installation of new, high-efficiency models.
- Congress should authorize DOE and EPA to provide incentives to state and local jurisdictions to adopt and enforce progressive water-efficiency codes and standards.

- State and local utility commissions should require utilities to provide and install smart water meters that can identify leaks in buildings and provide real-time feedback to consumers regarding their usage of water.
- Congress should consider legislation that requires compliance with new industry standards developed to help mitigate outbreaks of legionellosis and other diseases caused by water-borne opportunistic pathogens in building water systems.
- The federal government should consider a moratorium on mandating further flow rate and water consumption reductions for consumer plumbing products and appliances, pending research to investigate the effect of lower flows in water pipes on biofilm growth and the associated health and safety-related implications.

### **Water Reuse**

- Congress should instruct EPA to issue uniform “fit for use” water-treatment and water-quality requirements for the various indoor uses of non-potable water in and around buildings.
- NIST, EPA and industry stakeholders should conduct research to determine the best approach for the installation of dual plumbing systems in buildings.
- Utilities, consumers and state and local governments should support legislation mandating the installation of dual plumbing systems in areas where utilities are currently able to, or will be able to, provide recycled (reclaimed) water to buildings.
- DOE, EPA, NIST and industry stakeholders should support research on zero or near-zero-energy, water and waste for residential and commercial buildings.

### **Conclusion**

As highlighted in this report, both the public and private sectors in the United States can take steps to address the challenges of developing the U.S. building industry’s workforce and improving the nation’s water safety and efficiency. The building industry continues to move forward on implementing practices that support collaborative approaches in order to achieve high-performance buildings and communities. Federal agencies and Congress are participating in the collaborative dialogue, but now is the time for action. Implementing actionable solutions will significantly impact the nation’s ability to thrive economically and socially. Through the Consultative Council and other cross-industry groups, the building industry stands ready to create actionable policies and practices that support improving the building industry workforce and the safe, efficient and responsible use of water.

## About the Consultative Council

The Consultative Council assembles high-level building community representatives to make recommendations on behalf of the building community directly to the executive and legislative branches of government to improve our nation's buildings and infrastructure.

## Council Members

ASTM International

American Institute of Architects

American Society of Civil Engineers

ASHRAE

American Society of Plumbing Engineers

Associated General Contractors of America

Building Owners and Managers Association

Center for the Built Environment

Construction Specifications Institute

ESCO Institute

Estime Enterprises, Inc.

Extruded Polystyrene Foam Association

Glass Association of North America

Green Building Initiative

Green Mechanical Council

Grundfos Pumps Company

HOK

Illuminating Engineering Society

Ingersoll Rand

International Association of Lighting Designers

International Association of Plumbing and Mechanical Officials

International Code Council

Laborers' International Union of North America

NEBB

National Insulation Association

National Opinion Research Center at the University of Chicago

RCI, Inc.

Royal Institution of Chartered Surveyors

United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry

For more details on the Council, visit: <http://www.nibs.org/CC>.

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