Impact of Municipal, Industrial, and Commercial Water Needs on the Energy Water Nexus: Challenges, Solutions, and Recommendations

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Foreword

Limitations on water availability are emerging as a major restraint on economic development around the world. Even the United States can no longer assume every region will have enough water to meet energy, agricultural, industrial, and municipal needs. By addressing its own domestic water challenges, the United States will develop technologies and techniques that could easily be leveraged to address similar challenges in other corners of the globe. With leadership, technology development and deployment, and new institutional arrangements, the United States can be instrumental in resolving these many energy and water issues to build a more resilient, cleaner, and energy efficient future.

For the past two years, the Atlantic Council's Energy and Environment Program has extensively studied the issues at the core of the "energy water nexus." In May 2011, the Council analyzed the nexus from the perspective of electricity production. Six months later, the Council organized a workshop focusing on the nexus as it relates to the extraction and processing of primary and transportation fuels. In June 2012, the Council convened a third workshop to explore the nexus from the perspective of the efficient use of water and energy in municipal, commercial, and industrial water treatment and delivery systems. This work, along with other efforts, will form the backdrop for our efforts in China, India, and other emerging economies over the next several years.

This report, titled "Impact of Municipal, Industrial, and Commercial Water Needs on the Energy Water Nexus: Challenges, Solutions, and Recommendations," highlights the problems and potential solutions toward improving the efficiency of the water cycle and the energy used to support it. It also makes recommendations designed to enable water and wastewater authorities to provide water safely, efficiently, economically, and sustainably in the coming decades.

This workshop and report were made possible thanks to presentations—for which the Council is most grateful—by experts from Capitol Hill, several US government agencies and laboratories, as well as industry and academic representatives, and leaders from the non-governmental organization community. Thank you also to those who attended the workshop as participants.

Frederick Kempe

President and CEO
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Executive Summary

In the public's eye, water may be an invisible component, but it is nonetheless crucial to unleash the fuels for power and transportation, and to provide the heat and electricity used throughout the American economy. Energy is also an invisible but essential component for making water available for municipal, industrial, and commercial users.

Even if not front and center in the public's mind, there is an unbroken chain of energy for water and water for energy. Today, however, this circle may be broken if certain realities are not taken into account. The summer of 2012 highlighted some of these realities: Droughts lowered water levels in the Mississippi so that barges carrying transportation fuels went aground; floods damaged power-supply lines; and high temperatures warmed waters so much that some power plants had to reduce electricity production.

Other realities will negatively impact the provision of water supplies to the public for drinking and recreation, and to commercial and industrial entities for their operations, including the following:

- While there is an impressive array of drinking and wastewater systems across the United States, their ownership and management are fragmented.
- These water and wastewater utilities face significant and increasing costs for energy.
- As water-treatment standards become stricter over time, and as the US population grows, demands for water and energy will soar.
- The integrity of the US water infrastructure faces multiple challenges that will be costly to repair and upgrade, and these improvements are not being adequately funded.
- A series of seemingly unending and unfunded mandates and new standards will further challenge utilities' abilities to finance system changes.
- Water supplies are stressed in some areas and scarce in others, all while water demand is growing, not abating.
- Changing hydrologic conditions across the United States compound the difficulty of providing supplies to keep up with growing water demand.
- Underpriced water leads to both waste and shortages in funds for upgrades.
- Analytical data and models to improve good planning are inadequate.

Strategies, technologies, and examples of programs that will more effectively manage these negative impacts on the water cycle include the following:

- Water demand can be reduced through conservation, new price signals, reducing leaks in the pipelines, and by reusing water supplies.
- Local water supplies can be increased and augmented by conjunctive management strategies, construction of new dams and reservoirs, and new water sources from recycling and desalination programs.
- The water cycle can become more efficient by pumping less water and pumping it more efficiently.
- Increasing opportunities for biogas cogeneration at wastewater-treatment plants are opening up new energy supplies that may both offset rising electricity costs and provide added environmental benefits by reducing air and groundwater pollutants.

- Reducing urban runoff and increasing stormwater capture will reduce electricity demands and improve water conservation.
- Large energy- and water-efficiency gains can be achieved through the development of appropriate and effective codes and standards that merge the twin goals of saving both energy and water.
- The state of California has developed innovative public education campaigns and programs to help municipalities deal with energy water nexus issues.
- The Department of Defense is making headway with its Net Zero Energy Installation initiatives, and many of the solutions it develops can be applied in the civilian sector.

Taking into account the realities and solutions that can be brought to bear to help manage water-cycle issues, the Council puts forward a set of commonsense recommendations. Each is made with the end goal of supporting the economic and environmental health of the United States, while reaching a sustainable balance in providing the energy and water the country needs.

This can be achieved with continued commitment and dialogue among policymakers, consumers, stakeholders, and companies, to:

- undertake a public education and outreach program to provide the foundation upon which the US public will support needed changes;
- adapt the National Institute of Standards and Technology's Smart Grid Interoperability Panel as a framework for establishing smart energy and water standards and codes;
- take advantage of opportunities to consolidate the water industry and then improve coordination between the electric and water utilities;
- encourage US companies and government agencies to develop integrated water and energy stewardship plans;
- establish a best-practices organization to support water utilities to collect data on, evaluate, and teach evolving best practices;
- integrate energy and water planning (which will require more data to be collected and better analytical models to be developed);
- encourage Congress to provide the needed legislative support to reduce the barriers that can unleash private-sector financing for water-system infrastructure needs;
- support essential research and development (while many of the needs have been publicized, there is still a need to prioritize tasks, spread responsibility for the work, and better use R&D funds); and
- bring attention and continuing support to the significant efforts performed by myriad organizations working to solve energy and water nexus issues.

Sustainable energy and water policies and programs require a new paradigm—one based on water becoming invaluable, not invisible. This paradigm will be supported by:

- realistic efficiency, conservation, and reuse strategies;
- policy and funding mechanisms that lead to more-effective water resource supply;
- holistic/integrated planning between water and energy industries;
- using more clean technologies;
- leveraging partnerships;
- public acceptance of infrastructure investment and conservation measures;
- federal government efforts to craft a national energy strategy framework; and
- private-sector leadership.

1. Setting the Stage

One: The Water Cycle

The circular relationship between energy and water is demonstrated in the water cycle, just as it is in the power-generation and primary and transportation fuels sectors. While water can be tapped directly by some energy end users, the water industry provides the vast majority of water to this sector for exploration, fuels extraction and processing, hydraulic fracturing, refining and purification, steam, cooling, hydropower production, and for cleaning solar panels. Significant amounts of energy are supplied by the electric power and oil and gas industries to the water and wastewater utilities for heating, pumping, pressurizing, purification, and aeration of water supplies. Figure 1 depicts the water cycle.

Water is used by customers in the residential, commercial, municipal, energy, and industrial sectors. The most recent national data show that 345 billion gallons of water per day (BGD) are withdrawn, and over 100 BGD are consumed. Consumption is the key number, since withdrawals are returned to local water supplies and consumed water is withdrawn from its hydrologic source and cannot be used again. Water withdrawals for power production roughly equal those for irrigation. An overwhelming amount of the water consumed in the United States is for irrigation—not energy—purposes. Table 1 provides a summary of US water usage.

Figure 1: The Water Cycle[1]

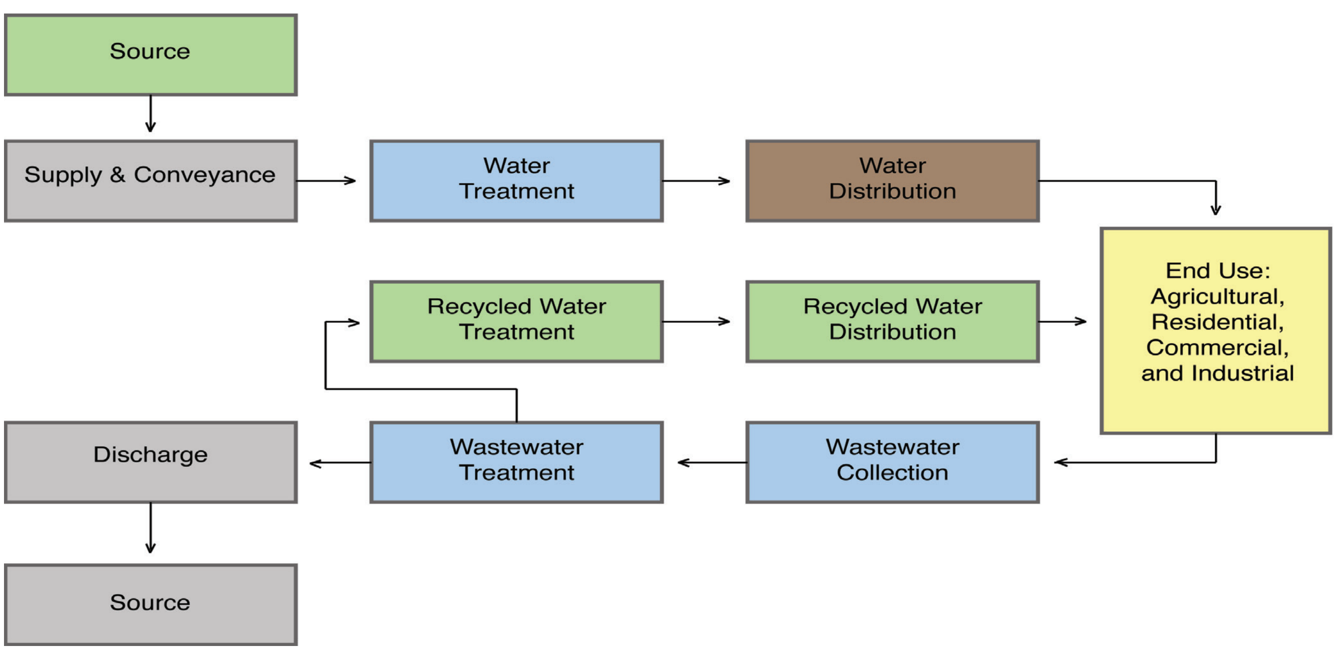

Table 1: Summary of US Water Consumption and Withdrawals[2]

100 BGD Consumption:	345 BGD Water Withdrawals:
• 80.8 billion for irrigation	• 138 billion for irrigation
• 7.1 billion for domestic uses	• 135 billion for thermoelectric power
• 3.3 billion for thermoelectric power production	• 48 billion for public and domestic supply
• 3.3 billion for industrial purposes	• 17 billion for industrial supply
• 3.3 billion for livestock	• 3.5 billion each for aquaculture, livestock and mining supply
• 1.2 billion for mining	
• 1.2 billion for commercial uses	• 3.5 billion other

Two: Water and Wastewater System Infrastructure

The US wastewater system comprises 16,000 publicly owned wastewater-treatment plants, over 100,000 major pumping stations, 600,000 miles of sanitary sewers, and 2,000,000 miles of storm sewers. It is estimated that the average American creates 100 gallons of wastewater per day.[3]

The clean drinking water production and distribution system is supported by a similarly impressive array of infrastructure.[4] There are approximately 155,000 public drinking-water systems in the United States, some of which serve only a few thousand customers.[5] These water “systems” are scattered across the country, and most are separately owned and operated.

Three: Energy Demands of Water and Wastewater Systems

Water and wastewater utilities require significant amounts of electricity to withdraw, pump, treat, and deliver water supplies, and to collect, treat, and clean the wastewater.

Nationwide, 4 percent of US power generation is used for water supply and treatment.[6] Between 85 to 99 percent of water utilities’ energy consumption is for pumping water. Every 1,000 gallons of water requires between 0.25 to 3.5 kilowatt-hours (kWh) for delivery to the customer. The water industry consumes over 100 million megawatt-hours (MWh) of electricity annually.

While electricity costs for the utilities vary from region to region, they are second only to labor costs. A 2009 study by the American Water Works Association found that electricity costs at ten major water utilities range from 12 to 28 percent of total operation and maintenance costs.[7]

The California Energy Commission produced a study in 2005 pinpointing the extent of the energy required to meet the state’s water demands. In addition to a large amount of diesel fuel, a surprising 19 percent of the state’s electricity and 30 percent of its natural gas consumption went to meet water-related energy demand.[8]

Water utilities’ energy demands will increase. Drinking-water treatment standards will become stricter and require more processing energy (e.g., for improved arsenic removal). Population growth will lead to pumping water longer distances and from greater depths because clean water supplies are unlikely to keep pace with demand. According to a 2002 Electric Power Research Institute study,[9] energy use for public and commercial water supply and treatment will follow the rate of population growth, while energy use for water supply and treatment—for both the industrial sector and irrigation needs—will triple from current demand.[10]

Predicting future demand is uncertain. One variable is the extent to which energy-intensive water-treatment methods such as desalination are used. Moreover, the current practice of overtreating water supplies leads to inflated demand, adding to projection uncertainties. More than 80 percent of the water from a wastewater-treatment plant is cleaned to drinking-water quality standards. Only 2 percent of clean drinking water is actually consumed for drinking and cooking due to losses in the delivery infrastructure and the fact that much of the drinking-quality water is used for household utilities.[11]

2. Water Sector Challenges

One: Water Infrastructure Is Deteriorating and Costly to Repair

The US water infrastructure faces multiple challenges. First, the pipe networks are nearing the end of their useful life and must be repaired or replaced. Second, water-treatment plants and storage tanks must be replaced or upgraded at a minimum in order to comply with new and more-stringent drinking-water quality standards. Third, new systems and programs must be developed to deal with wastewater and stormwater. Moreover, increasing population, heavier in some regions of the country than others, will require new water infrastructure.

Millions of gallons of polluted waters are poured into US freshwater systems every year, due to both substandard infrastructure that may not properly clean the wastewater, and old, leaky pipes. Municipalities face problems such as combined stormwater and sanitary sewer overflows. Due to the poor condition of the infrastructure, the average water system loses 16 percent of its water during the delivery process.[12] In the United States, thirty-five water utilities had a 15 percent leakage rate in 2003.[13]

Not only is the US infrastructure deteriorating, but it will also be costly to repair. Large capital investments will be required. Estimates include:

- It is reported that there are over 700 communities that face costs of $1 to $5 billion per community to fix the combined sewer overflow problems.[14]
- There are estimates that the cost to fix the country's clean-water infrastructure over the next twenty years may exceed $400 billion.[15]
- In 2002, the Environmental Protection Agency (EPA) estimated that capital needs for clean water from 2000 to 2019 range from $331 billion to $450 billion, and capital needs for drinking water over the twenty-year period range from $154 billion to $446 billion.[16] A subsequent 2004 EPA "gap analysis" found that water-infrastructure needs for drinking water will range from $204 to $450 billion.[17] The 2004 "gap analysis" estimates that a $10 to $30 billion annual investment is needed for clean water, and a $16 to $22 billion investment is needed for wastewater.[18]
- In 2009, the American Society of Civil Engineers pointed out that the United States faces an annual shortfall of $11 billion to replace drinking-water infrastructure (in addition to the investment needed to meet future water demands).[19]
- The American Water Works Association reported in 2012 that the cost of repairing and expanding US drinking-water infrastructure will exceed $1 trillion over the next twenty-five years. Through 2035, investment needs will top $108 billion in the Northeast; $172 billion in the Midwest; $507 billion in the South; and $237 billion in the West.[20]

While water- and sewer-infrastructure investment upgrade needs are burgeoning, investment dollars are not flowing into the system as fast as the water leaks out. Federal dollars for state loan programs face cuts due to budget pressures. For example, the EPA, which administers the Clean Water and Drinking Water State Revolving Funds, as of this writing, has provided only $2.4 billion in funds for state loans to help finance over $6 billion annually in upgrades. The EPA's FY 2013 budget proposal reduces the funding level by 15 percent. Budget pressures are expected to continue for the foreseeable future.

Two: Unending Mandates, Changing Policies, and Increasingly Stringent Standards

In the future, wastewater utilities will be facing more-stringent requirements to remove pollutants from treated waters and to control pollutants from urban runoff. The EPA has increased its efforts to force municipalities to upgrade their infrastructure in an attempt to prevent combined sewer overflows, which often occur because of wet weather or other extreme weather conditions. It has initiated a national rule-making process to regulate stormwater discharges from new or redeveloped sites, as well as increased its stormwater program regulations. Further, the EPA is considering setting more-stringent effluent limits for nutrients in waters treated at wastewater-treatment facilities. On top of those requirements for wastewater plants, many municipalities are facing increasing regulatory requirements and standards for drinking water.

Local municipalities are being required to provide most of the capital to finance the infrastructure improvements through loans, grants, bonds, and user fees. Many new federal government mandates are not accompanied by federal grants or loans. Because the resources of municipalities and local residents are strained by the recent recession, they are encouraging the federal government to support creative ways for the local governments to finance the debt required to fulfill the mandates.

Three: Insecure Water Resources Facing Future Demand Increases

Water demand will grow to meet increasing population requirements for freshwater and to produce an increasing population's growing electricity needs. Water demand related to energy is increasing at a fast pace, perhaps by as much as 50 percent more than today's needs by 2030.[21] This high rate of growth is due to increasing energy-intensive water-treatment requirements; the conversion of diesel agricultural pumps to electric; more long-distance water transfers; and changing irrigation methods that are more energy-intensive.

Since 1980, few new reservoirs have been built in the United States, and surface water storage (and withdrawal capacity) has remained constant. US freshwater resources will be limited without new storage capacity (which is yet another uncertainty). Water reclamation and reuse could provide sources of future water supplies. However, regional shortages are still likely.[22] For example, in some areas, water supplies will be reduced due to changes in water-sharing arrangements. In California, future water supplies will be limited due to changing water allotments within the Colorado River Compact. In the past, California received more water than its allotted shares because others in the Compact did not need the water. Today, while California will continue to receive its allotted shares, it will not receive the extra water it needs, as demand is increasing in Arizona and the Colorado River Basin.[23] In other areas such as Texas and the Midwest, water shortages are resulting from extreme droughts.

Four: Changing Hydrologic Conditions

Government and private-sector organizations are evaluating potential hydrologic cycle changes and their impacts on the availability of water (and energy).[24] Changing hydrologic conditions will create uncertainties when it comes to pinpointing future water demand and availability.

The impacts will vary from one region of the country to another. For example, temperature increases in the mid-latitudes of the United States will impact water availability and increase power demand—both of which multiply effects on each other. Current drought conditions—mainly due to a cold cycle in the eastern Pacific Ocean, which has decreased precipitation especially over the western regions of the United States—has led to power-plant reductions, crop losses, wildfires, impediments to waterway transport by barges, and damaged energy and water transmission infrastructure. While this Pacific cycle is expected to last for one or two decades, in the future, climate-change impacts may further impair hydrologic conditions.[25, 26]

The Natural Resources Defense Council found that, under the business-as-usual scenario of demand growth, water supplies in 70 percent of US counties may be at risk to climate change, and approximately one-third of counties may be at high or extreme risk. The study concludes that the geographic extent of potential risk to water supplies is greatly increased when climate change is considered.[27]

Potential hydrologic-change impacts pose challenges to water and wastewater utilities in fulfilling their public health and environmental missions. Projected changes in weather conditions and potential impacts on the water sector include:

- rising sea levels, which could penetrate freshwater aquifers and degrade their quality;
- reduced total annual rainfall and snow and glacier water storage, which affects annual supply in downstream areas;
- increased droughts and floods, both of which can negatively affect freshwater supply;
- droughts that reduce public water supply reservoirs; and
- forest fires in drought-stricken areas, which can damage water-supply lines.

Five: Underpriced Water

When it comes to water and sewer payments, US households have historically received subsidized rates that do not reflect true costs. As a general rule, the price of water does not reflect the value of the energy embedded in it for pumping, treating, and moving it.

The effect of underpriced water is waste, and investment-upgrade funding shortages. Water customers across the board have little incentive to conserve or use water efficiently. Moreover, utilities do not generate the revenues needed to self-fund necessary infrastructure upgrades. Ironically, utilities that launch successful programs to help customers conserve water see decreased revenues.

Going forward, prices need to be set at levels that will reflect the costs of providing the service.[28] A new paradigm—that prices water to encourage efficient use and generates income for maintaining quantity and quality—should be based on decoupling revenues from unit sales/earnings. Meanwhile, innovative investment vehicles can help the water utilities obtain the needed upgrade funds. Such funding would be paid back over time, reducing the pace of water-price increases needed to fund infrastructure improvements. Regulatory policies can also reward investments in end-use water and energy efficiency, which would likewise reduce the pace of price increases. The reality is that creative financing options are crucial, since price increases by elected regulators are not politically popular.

Six: Water Supply and Use Data Lacking

Analytical data is a fundamental tool in making good planning decisions; however, there is insufficient data of the type and form needed to effectively evaluate programs and products. The tools and methodologies are not ready to perform the necessary tasks. Data and analytical methods, models, and tools are needed to optimize multiple resources and the economic and environmental goals in an integrated way.[29]

According to a draft report often referred to as the “Sandia roadmap report,”[30] the US government has created a good foundation for data collection. The National Water Information System, provided by the US Geological Survey organization (USGS), provides access to surface- and groundwater resources data collected at approximately 1.5 million sites throughout the United States. The USGS National Water-Use Information Program (NWUIP) is the main source of information about water use through its five-year national summary of estimates of aggregated water use, compiled primarily by counties and states. However, the quality of the data is not consistent, specific data are not always available, and estimates of water supply and use are made at varying spatial scales.

3. Solutions for Creating a Sustainable Balance in the Water Sector

One: Reduce Water Demand

The Council's reports on the power and fuels sectors' water-related issues identified areas where water demand can be reduced.[31] For example, water withdrawals and consumption can be reduced by the dry-cooling of power plants; by utilizing produced waters from oil and gas drilling for process water at fracking sites; and by recycling water in as many operations as possible. Agricultural water conservation, through efficient irrigation techniques, can also significantly reduce water demand. (Although the latter may increase energy demand due to the energy required to pressurize the irrigation systems, on balance, reducing water requirements could offset greater electricity requirements.) Likewise, urban water conservation can lead to both water and energy savings. In the water- and wastewater-treatment sectors, several approaches can be used to reduce water demand, including:

- conservation programs;
- incorporating price signals for water and sewer services that will reduce demand;
- reducing leaks in the delivery system; and
- reusing water (e.g., by using gray water for non-potable water requirements).[32]

Two: Increase Water Supply

There are several ways to increase and fortify local water-supply sources, including:

- conjunctive management of surface- and groundwater resources;[33]
- construction of new dams and reservoirs for increased surface storage;
- water recycling and reuse; and
- desalination.

Water recycling can be achieved in several ways. There may be potential for reuse of the large quantities of water unleashed in unconventional oil and gas production with improved technology and integrated planning. This "new supply" of water could help meet freshwater demand by agriculture, and free it up for other municipal, commercial, and industrial water customers. In Western regions where produced waters can be of relatively high quality, it could be used to irrigate lands where cattle graze. The water industry will have to develop cost-effective and water-efficient technologies to treat the produced waters, which often contain higher concentrations of salts.[34]

Additionally, wastewater can be treated and cleaned to the requirements of the end user to meet non-potable needs. These recycled supplies can substitute for freshwater in power-plant cooling, industrial processes, and landscape irrigation. "Gray water"—the wastewater from residential, commercial, and industrial sinks, showers, and clothes-washing machines—can be treated and reused on-site. Appropriate personal-care products and on-site treatment facilities are required to make gray-water recycling possible.[35] Finally, treated waters can be recycled by recharging groundwater aquifers and/or augmenting surface-water reservoirs after the wastewater is treated to potable drinking-water quality standards.[36]

The National Academy of Science's Water Science and Technology Board released a report assessing the impacts of wastewater recycling on the US drinking-water supply. While the report raises important national policy questions about the adequacy of health safeguards, it puts into perspective the positive impact that this type of recycling can have on US water supplies. The National Academy of Sciences found that out of the 32 billion gallons of wastewater discharged daily, municipalities dispose of 12 billion gallons into public waterways. Using current technology, reusing this discharge could augment the US public water supply by 27 percent. This would unleash a significant amount of supply for water-strapped cities and farmers.[37]

Urban areas that face high energy and treatment costs for current water supplies may turn to desalination. This process removes the salt from brackish or saltwater supplies. Desalination is growing at a 10 percent annual rate. There are desalination plants in over forty states, with most of the newer plants being built in the 5- to 20-million-gallons-per-day capacity. Several plants are being designed for capacities of up to 50 million gallons per day.[38]

In conclusion, wastewater reuse and desalination could provide a significant "increase" in the US water supply, as desalination is growing at 10 percent per year and wastewater reuse at 15 percent per year. Approximately 2 BGD of wastewater is being reclaimed and reused today. At current growth rates, wastewater reuse and desalination water consumption together could reach about 16 BGD by 2020, which would equal all current nonagricultural freshwater consumption in the US.[39] However, it must be recognized that nontraditional water usage will be energy-intensive.[40]

Three: Lower the Energy Intensity of the Water Sector

The energy intensity of each water-cycle segment is difficult to quantify because electric and gas meters do not measure water-related uses specifically. Energy intensity depends on the location of the water utility. While the energy-intensity range shown in Table 2 pertains only to California, it is instructive as to both the difference in electricity needed for each water-cycle segment, and just how wide the range is. The key variables in energy intensity are climate, topography, and end user.

In addition to saving energy by pumping less water, water may also be pumped more efficiently. Currently, 45 percent of the energy used by the pumps is wasted; this energy can be reduced to less than 20 percent by adding variable speed drives, replacing impellers, and installing more-efficient motors in the pumps. Other efficiency measures include:

- maximizing pumping during off-peak hours to more efficiently use the electricity resource;
- researching hydrokinetic opportunities to take advantage of energy in water by, for example, installing turbines in pipes; and
- improving the pressure management of distribution systems.[42]

In wastewater-treatment plants, energy can account for 25 to 40 percent of the total operating cost of a facility.[43] Activated sludge processes (fans/blowers) account for more than one-half of the energy consumption at typical wastewater-treatment facilities. Pumps also consume a large share of energy, generally requiring about 15 percent of total plant use.[44] Cost-effective interventions to reduce energy intensity in wastewater-treatment plants include:

- installing more energy-efficient motor systems in pumps, aeration blowers, grinders, and mixers;
- implementing energy-management and -efficient

Table 2: Energy Intensities in the Water Cycle in California[41]

Range of Energy Intensity (Kilowatt-hours/MG)

Water Cycle Segments	Low	High
Supply and conveyance	0	14.000
Treatment	100	16,000
Distribution	700	1,200
Wastewater collection and treatment	1,100	1,200
Wastewater discharge	0	400
Recycled water treatment and distribution	400	1,200

designs in pump stations through right-sized pumps and reduced heads, and proper flow for process-cooling systems;
- metering and monitoring energy use; and
- lowering pressure in the pipe systems to reduce energy demand and leaks.[45]

Improved water-efficiency codes and programs are key factors in using energy more efficiently. They can establish more-efficient energy usage in systems that provide hot and cold water to homes and businesses, water-saving appliances and fixtures, and in the buildings themselves. The Alliance for Water Efficiency estimates that from 2010 to 2029, cumulative electricity savings through efficiency gains could reach 170 gigawatt-hours (GWh). Annually the United States could save over 10,000 megawatt-hours (MWh) per year by 2019, and plateau at an annual savings of 12,000 MWh per by 2029.[46]

It is especially important to reduce the water-related electricity demand during peak load periods. A reliable electricity supply system is built to meet electricity demand at peak times, so there will inevitably be more capacity than is needed most of the time. This raises overall water requirements for power generation. Shifting the water demand to off-peak power periods will lower the peak electricity requirement, and reduce the overall water footprint of the power system. This would free up water to be allocated to other customers.

Water storage can help manage peak-load electricity demand. Pumped water storage is achieved by adding pipelines to connect a lower to a higher reservoir or lake, and pumping the water to the higher spot during off-peak hours. Electricity is then produced by reversing the flow during the peak hours. Pumped storage can reduce peak-load demand at water utilities if water storage tanks are refilled during off-peak periods. (The water utility reaps further benefits by reducing its electricity costs by purchasing the cheaper off-peak power.) Further benefits of pumped storage for the agricultural and urban sectors include irrigation districts lowering volumes in storage tanks, and urban areas adding storage tanks that can be refilled at off-peak hours.

Using renewable energy sources that use less water, such as wind and some solar systems, can reduce the energy intensity of providing water. Colocation of renewable energy production and water facilities can provide good synergies. Not only can on-site renewables reduce the amount of water used for electricity production, but treatment plants should also be less vulnerable to shutdown due to extreme weather disruptions to grid power supply. Several projects are under way across the United States to colocate renewables and water plants. CPS Energy and SunEdison recently completed two photovoltaic solar panel sites for a combined 19.8 megawatts (MW) of power at the Dos Rios Water Recycling Center, owned by San Antonio Water System in Texas.

Four: Produce Energy from Water

The United States already receives a significant amount of electricity from hydroelectric power facilities, and that capacity can be enhanced through improved runoff forecasting and other decision support models and tools. In-conduit turbines and other generating devices can be installed in the pipelines, canals, and aqueducts to boost power production. While the amounts may not be large, they can produce enough extra electricity to meet or offset the energy demands of the conveyance system.[47]

Biogas cogeneration at wastewater-treatment plants will provide new opportunities for producing energy from water. It is estimated that approximately 1 cubic foot of biogas per person per day can be produced at one anaerobic digester; the energy content of the biogas is 600 British thermal unit (Btu) per cubic foot.[48] Wastes such as sewage sludge, dairy manure, and food-processing residues including canola oil, grease, and cheese whey can be loaded into these anaerobic digesters. In 2010, it was reported that anaerobic digestion is used at 3,500 wastewater plants, and that 57 percent of water utilities recover biogas for on-site energy uses, primarily digester heating, electricity, and heating and cooling buildings.[49] The power can be used to supply electricity to wastewater plant operations, or it can be sold into the grid. In addition to offsetting electricity costs, converting wastes into energy has environmental benefits by reducing air and groundwater pollutants.

In 2011, the Water Environment Research Foundation (WERF) recommended that wastewater-treatment plants should not be considered as waste disposal facilities but rather as “water resource recovery” facilities that produce clean water, recover nutrients, and use renewable energy.[50]

It supports over twenty research projects for self-generation of power at wastewater-treatment facilities that it hopes will confirm the potential for a 20 percent improvement in energy, cost, and/or environmental impacts by optimizing wastewater and solids operations.[51]

While more research and development and test programs are required, there are wastewater-treatment plants that have achieved significant amounts of energy production. The East Bay Municipal Utility District in Oakland, California, and the Strass im Zillertal facility in Innsbruck, Austria, have both produced more power than needed at their facilities. Facilities in Sheboygan, Wisconsin, and Johnstown, New York, produce 70 percent of their power needs.[52]

In April 2012, the EPA recognized these and other potential benefits when it issued a statement on "Principles for an Energy Water Future"[53] that recognizes increasing synergies between energy and wastewater facilities by supporting the following policies:

- Using wastewater and associated organic solids and treatment by-products, such as methane gas, as a source of renewable energy that can be used by treatment plants to reduce net "on-grid" energy use, or to become zero net energy consumers;
- using wastewater for irrigation, accounting for the nutrients in the water as a way to reduce the need for additional fertilizers;
- recycling or reusing water for appropriate uses with no resulting loss of downstream use and habitat, minimizing energy used for treatment, and becoming a reliable source for the future; and
- extracting and recycling nutrients from wastewater.[54]

Five: Urban Runoff and Stormwater Capture Programs

Many of the metals and other pollutants that enter US water supplies come from urban water use and storm runoff. Reducing the runoff sent to wastewater-treatment facilities will reduce electricity consumption.

The California Energy Commission found that in California, storm runoff increases sewage-treatment requirements up to two times in winter months. It has documented that commercial buildings pump large amounts of water into storm drains unnecessarily (e.g., a building in Sacramento pumps 65,000 to 75,000 gallons of water into the storm drain daily). Significant amounts of clean water are wasted in urban areas on uses that do not require clean water. For example, during the summer peak months in parts of Southern California, 70 percent of all potable water is used to water lawns, after which the water runs off into the storm drains and other pipes. Southern California loses 13 billion gallons of water per year to urban landscape runoff.[55]

Enacting federal regulations to control runoff and capture programs is controversial at this time. The Clean Water Act, which turns forty in October 2012, is the main body of legislation which establishes the federal government's authority to control water pollution. Even though the law has existed for four decades, there are unresolved issues as to who has jurisdiction over setting regulations and requiring permits for storm runoff. The Supreme Court will rule on two cases in 2013 which will provide some clarification. The first involves whether the EPA can require permits for water running off logging roads. The second case turns around the question of what types of movements of stormwater in flood-control districts would trigger the EPA's permitting requirements. The Supreme Court has already ruled that permits are not required when an agency is moving/transferring water.

Six: Efficiency through Standards and Codes that Save Water and Energy

Large energy and water savings can be achieved through the appropriate development of energy- and water-saving codes and standards.[56] According to the American Council for an Energy-Efficient Economy (ACEEE), there are significant annual and cumulative water savings from existing water-conserving standards for appliances (such as showerheads, faucet aerators, toilets and urinals, clothes washers, pre-rinse spray valves, and dishwashers). As of 2010, annual water savings were 1.5 trillion gallons of water; cumulatively, the savings amounted to 11.7 trillion gallons of water. By 2025, the annual and cumulative savings for existing standards will be 1.5 and 38.6 trillion gallons of water, respectively. In 2010 alone, these savings were worth $10.8 billion, amounting to 9 percent of the total US public water supply withdrawals, and reduced energy use in water and sewage systems by 0.05 quadrillion BTU (quad).[57]

Table 3 shows both the energy and water savings that could be accomplished with future appliance standards under consideration. Compared to the annual savings of 1.5 trillion gallons of water in 2025 with existing standards, there is the potential to annually save an additional 430 billion gallons of water by 2035. At the same time, over 42 quads of energy could potentially be saved by 2035 with the adoption of these new standards.

It will be challenging to incorporate water-efficiency requirements into codes and standards. In the case of plumbing fixtures, for example, an efficiency standard can be established. However, its water profile will depend on "uncontrollables" such as the person/fixture ratio, type of occupancy where the fixture is placed, and the user's behavior (bad behavior is hard to control). For landscape irrigation equipment, water efficiency depends on location, post-installation behavior, and whether the purpose is for watering new plants or just maintaining established landscape material. Furthermore, measuring water use is not an exact science; accuracy depends on who reads the meters, and how. Accuracy is hard to gauge because most meters do not require sensitivity better than 360 gallons per day, and meters larger than three-quarter-inch do not measure low flows of water.[59]

History shows that codes and standards are continuously upgraded, based on experience and emerging needs. Because codes and standards are like software and require users to help fix the bugs, it is important to find the right balance in terms of stringency: too harsh, and no one will adopt; too lax, and the results are meaningless.

Seven: Learn from the Success Stories

California's Efforts to Address Energy Water Nexus Concerns

California has taken the lead on several fronts in the energy water nexus arena. As previously mentioned, it sponsored a landmark study in 2005 that took a comprehensive look at California's water sources and supplies, energy use in its water cycle, energy use by water end users, and the impact of water efficiency in energy supply.[60]

With significant data and a better understanding of its challenges, the California Energy Commission has developed a suite of programs concerning energy efficiency, technical assistance and financing, energy research and development, and promotion of innovative energy ideas. The energy- and water-related projects include:[61]

- IOUs to develop partnerships with water agencies to implement water-conservation and energy-efficiency programs, and to measure the energy savings achieved;
- investigating whether it will be possible to reduce electricity use by 10 percent with induction motors at water utilities;
- wastewater utilities are exploring ways to reduce energy use in aeration processes; and
- 20 percent loans from the Department of Water Resources and the Water Resources Control Board for green projects.

Table 3: Potential Annual and Cumulative Savings in Proposed Appliance Standards[58]

	Annual Savings in 2035				Cumulative Savings through 2035 (quads)
	Electricity (TWh)	Peak Demand (GW)	Natural Gas (TBtu)	Water (billion gallons)	
Standards due by Jan. 1, 2013	100	20	40	230	14
Feb. 2013 – Dec. 2015	210	50	200	200	27
Total	**310**	**70**	**240**	**430**	**41**

Department of Defense (DOD) Net Zero Initiative

DOD's Net Zero Initiative shows impressive efforts in tackling energy and water issues. Its programs serve as a useful guide as to how to create sustainable solutions, many of which can be applied in the civilian sector.[62]

The beginnings of the Net Zero Initiative go back to legislation enacted in 2005 that mandated federal government agencies undertake energy-, water-, and waste-efficiency measures. Executive Order 13514, issued by President Obama on October 5, 2009, expanded the guidance. For the DOD, the Order mandated that the DOD reduce its greenhouse gas emissions; design all buildings as of FY 2020 to achieve net zero energy use by FY 2030; reduce its water consumption by 2 percent annually, for a total of 25 percent by FY 2020; and divert at least 50 percent of its solid waste by FY 2015.

In 2011, the army asked its installations commanders for expressions of interest in starting a net zero energy, water, and waste pilot project. Over sixty installations submitted applications. For net zero water pilots, twenty-three applications were received. The army chose eight installations for net zero water pilot programs, including the Aberdeen Proving Ground, Maryland; Camp Rilea, Oregon; Fort Buchanan, Puerto Rico; Fort Riley, Kansas; Joint Base Lewis-McChord, Washington; Tobyhanna Army Depot, Pennsylvania; Fort Carson, Colorado; and Fort Bliss, Texas, and New Mexico.[63]

DOD's approach recognizes that to achieve a net zero energy objective, it must follow a holistic approach to reduce not just energy use, but three related components: energy, water, and waste. Key to DOD's strategy is a "systems of systems" approach, developing a holistic framework to accomplish its goals.

DOD's approach to net zero energy entails:

- dramatic demand-side energy use reduction;
- the right mix of energy-generation technologies and strategies that contribute to energy security;
- area/building clusters to be served by small, central utility plants; and
- the use of potential technology innovations and mission changes.

DOD's approach to net zero water relies on:

- identification and elimination of water inefficiencies, such as distribution system and evaporation losses;
- implementation of low-impact development strategies that retain stormwater runoff;
- development of water conservation awareness campaigns to change behavior;
- implementation of water-reuse strategies;
- inclusion of gray-water systems into new building designs where cost-effective;
- improvement of the security and reliability of infrastructure during external service disruptions; and
- establishment of alternate water supplies to the public water system.

DOD's approach to net zero waste requires:

- improved procurement practices, such as buying less, increasing the recyclable content, and reducing the packaging requirements of supplies;
- repurposing materials through donations of furniture or recycling building materials;
- installation of recycling centers;
- composting food waste and organics;
- pursuing energy-recovery strategies where economically feasible; and
- disposing of materials after all other options are exhausted.

The net zero strategy is accomplished through a series of audits, assessments, and flow analyses, followed by establishment of roadmaps for each energy, water, and waste goal. DOD uses multiple initiatives, including collaboration calls between the installations, pilot programs, webinars, and workshop training exercises. It partners with other federal agencies as well as the local and regional communities to find solutions tailored to conditions present at each installation chosen for net zero status. DOD also leverages private sector investment and financing vehicles to its advantage, including energy-savings performance contracts, utility energy service contracts, enhanced-use leases, and power purchase agreements. The Army's net zero program has led to innovative technology solutions, such as the Shower Water Reuse System, understanding needed culture changes, best management practices, and other lessons that can benefit the private sector.

4. Issues and Solutions Overview

Table 4 provides a critique of the current state of affairs in the water industry from the perspective of the energy water nexus. It synthisizes the myriad issues and comments on the panoply of solutions that are at hand.

Table 4: A Critical View of the Issues and Solutions

Issues	
Governance and Policymaking • Political and industry sectors have both failed to demonstrate leadership by developing and enacting solutions that are available today. • Federal government policies are not coordinated due to the myriad executive branch, legislative, and regulatory bodies involved in water issues. • Absent a full understanding of the energy and water nexus, priority is not given to addressing the sources of greatest pollution: agricultural runoff. • The US can ill afford to lose the opportunity for domestic energy production and economic growth by overregulating/cutting off access to water supplies for power and fuel production. • Policymakers lack data upon which to build sound policies.	**Industry Issues** • US water utilities may be highly regulated but their fragmented nature leads to bad behavior and decision-making. • The water industry lacks a strong lobby. • Water utility management could be improved with better-trained personnel and streamlined staffing. • Water utilities are their own worst enemy; they congratulate themselves on having the cheapest and best-tasting water rather than on having the most sustainable system for providing water to the public. • Water utilities have been slow to raise water prices to levels that encourage conservation and fund system upgrades.
Public Attitudes • Public complacency: The lack of both an understanding about the nature of the water issues facing the country and concern over looming water quality and quantity issues leads to inadequate public support to raise prices that could solve some of the problems. • Water is priced so low that it is not valued, conserved, or invested in. • Water is not viewed as a commodity but as a right of all American citizens. • The US national psyche does not accept regulation to improve community living standards (as is common in Europe), and Americans especially dislike regulations that raise prices.	**Water Quality** • Water-quality issues exist even though the public generally believes that the US infrastructure guarantees access to excellent water quality; public education about the state of the infrastructure may be warranted. • Water quality deteriorates the farther it is transported, and some water supplies near end users are too chlorinated for safe use. • Pharmaceuticals in the domestic water supply are an emerging issue.
Water Quantity • Changing hydrologic patterns are producing record drought cycles in southeastern areas of the United States. • Efforts are under way to better utilize gray or reclaimed water, but the infrastructure necessary to support its use ("purple pipe") is inadequate to meet such demands. • Crumbling infrastructure due to deferred maintenance leads to tremendous water losses, as well as revenue-stream losses. • The United States faces a "tale of two cities," wherein some cities have too much water and others face a scarcity situation. • The federal government does not adequately fund mandated infrastructure improvements.	**Inefficient Use of Energy in Water Sector** • The United States wastes energy cleaning water, since only 2 percent of the cleaned water actually goes toward human consumption. • Energy is wasted pumping water to end users due to inefficient pumps and leaky pipes. **Technology Adoption** • Technologies are available to make energy and water more efficient, but building and system operators either do not know about them or have no incentives to put them to use. • The United States is a decade or more behind Europe in adopting new technologies and efficiency measures.

<table>
<tr><th colspan="2">Solutions</th></tr>
<tr><td>Public Education
• Access to better information about local water quality is needed.
• Arm “smarter consumers” with just enough (and not too much) water-quality information to make better home-water-use decisions.
• Change public perceptions through better lobbying and communication efforts.
• Moving the energy-water nexus issue further up the political agenda will require the issue to move up on the public’s agenda.
• Expand the EWN discussion to become an energy-water-waste-nexus discussion.</td><td>Wastewater Initiatives
• Harness the nutrients in wastewater as fertilizer and use wastewater for farmland irrigation.
• Extract and recycle the nutrients in the wastewater.
• Use the organic solids and treatment by-products, such as methane gas, as sources of energy at the wastewater-treatment plant to reduce its grid demand and perhaps allow the wastewater utility to become a net zero energy facility.</td></tr>
<tr><td rowspan="2">Water-Related Initiatives
• Many problems can be solved with currently available technology.
• Water reuse / gray-water usage / designer water, ie. tailor purity of the water to the end user’s requirements.
• Take advantage of local water resources to the extent possible via rain harvesting and recycling supplies.
• Industrial sector can decrease water consumption through reuse and zero discharge.
• Change chemicals used in water treatment to improve quality of the water that must ultimately be discharged back into the environment.
• Industry can take hold of a golden opportunity to put in new water-treatment technology facilities in areas that are re-industrializing due to the availability of more-affordable / domestic energy supplies.
• Utilities can reduce water losses through pipe and infrastructure upgrades.
• Patented water-treatment technologies are available to both reduce water usage at fuel-extraction sites and to clean the discharge water; public awareness must be increased.
• Enhanced oil- and gas-recovery operations—now feasible due to technology and economic conditions—will lead to decreased water needs for fuel production, and perhaps even more importantly, may result in new sources of water for agriculture from the “produced waters” in Enhanced Oil Recovery.
• More desalination projects should be pursued.
• Utilities must implement best practices and available technologies.</td><td>Federal Energy Policy
• The federal government must adopt sustainable energy and water policies.
• Tax policies can be enacted to help communities and industry make infrastructure improvements.</td></tr>
<tr><td>Appropriate Government Role
• The government needs to develop codes and standards that will lead to efficiency, which translates into savings of energy, water, and, ultimately, money.
• The government needs to develop good data collection methods regarding energy and water usage in the supply of water to public and industrial users, as well as water quality on the local level.
• State-level grants for infrastructure improvements must be tied to guidelines and performance metrics.</td></tr>
</table>

Solutions (Cont.)	
Energy-Related Initiatives	**Industry Assumes Leadership Role**
• Design and install more energy-efficient pumps. • Many problems can be solved with currently available technology. • Colocate transmission and water pipelines. • Utilities need to invest in or develop on-site renewable energy sources for wastewater treatment when it reduces the electricity budget. • Waste by-products are an increasingly attractive source of energy (e.g., biomass and FOG digesters that produce methane). • Educate engineers and building operators about available technologies. • Utilities must implement best practices and available technologies.	• Industry must show that it intends to find solutions in the public interest and communicate this leadership commitment to Congress. • There are leadership institutions and models in other industries that can be explored; for example, the nuclear industry's trade group has undertaken a successful public education program and sponsors an organization that identifies and teaches best practices.
Regulatory Policies	**Pricing Policies**
• Develop commonsense solutions based on the reality that money (saving it, access to it, and making it) are the drivers in the US marketplace. • "Set the goalposts as higher"; tougher regulations may be an easier pathway to increase prices to an appropriate level. This will drive conservation and needed infrastructure investments more effectively than requiring water regulators (who often must be reelected) to make tough political decisions in order to raise prices. • Industry can set its own voluntary but strict standards rather than wait for regulatory agencies to act. • Regulations such as zero discharge requirements can drive sustainability as well as increased domestic fuel production. • Examine European practices that might be adopted in the United States.	• Explore price elasticity of water to find the right blend of incentives and penalties that will drive good water behavior. • Focus on US success stories as an example that local constituencies can accept—and have accepted—higher water prices in order to improve local water quality. • While it is useful to take advantage of water-quality crises when they arise, sell higher water prices that lead to service improvements on the basis that it gives a company or city a competitive advantage.

5. Recommendations

The previous three sections examined water-cycle issues and solutions. In this section, the Council puts forth commonsense recommendations that are based on the presentations and discussions at the Watts and Water workshop.

These recommendations build on those made by the Council to address the energy-water nexus from the perspective of both thermoelectric power supply and extraction/processing of primary and transportation fuels. These sets of recommendations can be found in Appendix A.

All of the recommendations are made with an end goal of supporting the economic and environmental health of the United States while reaching a sustainable balance in providing the energy and water the country needs. Achieving a cost-effective sustainable balance will require continued commitment and dialogue among policymakers, consumers, stakeholders, and companies.

One: Public Education and Outreach

Public awareness of the energy water nexus is a fundamental building block to change the way water and energy are used and conserved across the United States. However, the US public is not fully informed about:

- how much energy is consumed in each aspect of the water cycle;
- how much energy—not just water—can be saved through water conservation;
- how the price of home water supplies is subsidized by taxpayers; and
- how much it will cost to upgrade the current system and meet new water-quality demands desired by the public.

Without a full and complete understanding of the issues, and the fact that the resolution of energy water nexus problems will require integrated strategies, there will not be adequate public support for the necessary changes. The public needs access to a solid foundation of knowledge; both public institutions as well as the water and energy industry have a role and incentive to better communicate information to the public. The EPA's "Principles for an Energy-Water Future" supports "[r]elying on education and outreach, in collaboration with local communities, to be at the forefront of encouraging efficiency."[64] More than twenty years ago, the Association of California Water Agencies (ACWA) recognized the need in California to elevate public education and outreach efforts in order to meet emerging energy and water goals, concluding: "When you need to move the public toward solutions, education is the key."[65]

Much can be learned from the experiences and insight gained from ACWA's campaigns. It first sought to build awareness of the issue. Next, it realized that public opinion research was needed to gauge what the public was thinking, and what messages would resonate. It built campaigns based on knowing its audience, assessing who was going to reach each audience, and then providing the necessary tools. ACWA designed numerous programs on a variety of topics and for many different media.

For success, a public outreach campaign:

- must be built on appropriate and diverse coalitions;
- should educate the public about the current issues,

and the fact that solving them will lead to a more prosperous US economy;
- leverages the young generation's desire to spearhead changes that will lead to a better environment; and
- develops an easy-to-understand and resonating message about water's value and scarcity.

Two: Adapt National Institute of Standards and Technology (NIST)'s Smart Grid Interoperability Panel (SGIP) as a Framework for Setting "Smart" Energy and Water Standards and Codes

Government agencies play an important role in setting appropriate standards and codes. Innovative voluntary agreements by water industry stakeholders can inform and influence these regulations, and can add to those already promulgated by the DOE's "EnergyStar" and EPA's "WaterSense" programs. At the workshop, there were calls for DOE to better integrate water into its appliance and equipment energy-efficiency standards.

There are tremendous opportunities to incorporate energy- and water-efficiency standards into building codes and in the design of community public spaces. Green homes can save water and energy through changes to lighting practices. Green communities can incorporate rain gardens and on-site stormwater collection that in turn can provide water to the community and decease energy costs associated with stormwater treatment.

Industry (including the building industry through organizations such as the US Green Building Council, International Association of Plumbing & Mechanical Officials, and the National Association of Home Builders) can take the lead role in the development of voluntary programs to lay the groundwork for "gold" water standards and codes.

The key question becomes how to get a large number of stakeholders, companies, and government agencies to agree on what these gold standards and codes should be. As discussed above, industry could voluntarily meet and agree on what the tough rules should be; however, because of the number of stakeholders that must "buy in" to these standards and codes, their development should reflect all of the myriad voices.

The NIST Smart Grid Interoperability Panel paradigm may provide a good framework and roadmap for how to achieve energy- and water-efficiency gold standards (a term loosely used as both codes and standards are important). After the United States adopted a smart grid goal in the 2007 Energy Independence and Security Act, NIST initiated a process that has established the standards as to how to create a smart grid. It began by identifying an initial set of existing consensus standards and then developed a roadmap to fill the gaps; next, it established an "interoperability panel," which was a public-private forum with a governance structure to shepherd the effort. NIST then developed a conformity framework for testing and certification, and is now working on a self-sustaining business plan.[66] Evaluating the model and the reasons for its success[67] can provide a valuable example for how water stakeholders can attain their goal of raising the bar on codes and standards.

Three: Industry Consolidation and Coordination between Electric and Water-Treatment Utilities

Given the fragmented nature of the water systems in the United States, there may be opportunities for consolidation that could lead to great benefits of economy of scale. Over 93 percent of small water systems (those which serve fewer than 10,000 people) are within five miles of each other; 100 percent of the systems are within twenty miles of another system.[68]

Greater efficiencies and cost savings can be achieved if the separate water, wastewater, gas and electric utilities, and other companies in the energy industry could align their goals and programs. Currently, the wastewater utilities focus on cutting costs for collection, treatment, and water disposal, whereas the water utilities value reductions for treating and delivering water. The electric and gas utilities focus on saving electricity and gas, respectively. If all utilities value saving both water and energy, the multiplier effect would lead to a more-sustainable energy water nexus. The end users in the industrial, corporate, and agricultural sectors also need to work together with energy and water industries. All players should proactively address their energy and water needs.

Four: Integrated Water and Energy Stewardship Planning

Just as collaboration between the energy and water industries is essential to establish sustainable growth, so too is integrated planning by all US companies. Businesses in the energy and water sectors understand that access to water and the availability of affordable energy are key business risks that must be addressed in the development of strategic plans. To maintain the US economy's access to both energy and water, these resources must be used in the most efficient manner possible by all companies, be they in the private or public sector. Each institution must develop integrated energy and water stewardship plans.

Development of integrated plans begins with an assessment of the energy and water risks in the organization's supply chain, in production areas, and on how their products are used, paying particular attention to the watershed context in which the energy and water are obtained. Risks are not limited to the physical lack of access to water or energy, but also include regulatory compliance and brand reputation. Furthermore, these risks have bottom-line balance-sheet consequences that also must be quantified. Addressing these risks will bring to light opportunities for companies to save money and improve brand perception.
Board-level commitment to "pursuing sustainable policies" alone will not suffice; the key will be the extent to which an institution integrates the personnel responsible for designing energy and water strategies into its decision-making structure. Companies need to give more than lip service to this imperative; its sustainability leaders must be given the necessary authority to institute efficiency measures that can be counted toward improving the company's bottom line and reputation, not just its regulatory responsibilities.

There is ample room for improved coordination between the myriad federal agencies as described in the Council's two previous energy water nexus reports.[69] For example, the DOE and the EPA could jointly promote their respective EnergyStar and WaterSense voluntary programs. Furthermore, federal government agencies can improve their coordination with complementary state agencies and better share the data collected by federal agencies with their state-government counterparts.

Five: Water Industry Best Practices Organization

A common theme heard throughout the Water and Watts workshop was the need for better workforce training, from management on down. Concern was voiced that some utilities' staff do not have adequate knowledge about product technologies and/or new information technology tools, the availability of energy- and water-efficient products, and energy-use data for their operations. It was reported that some utility operators are reluctant to change their practices.[70] Given the fragmented nature of the industry, and the fact that many utilities are staffed with part-time employees, these issues are not surprising; however, they can be resolved.

Establishing an umbrella organization to collect information, help evaluate, and teach evolving best practices would benefit 16,000 publicly owned wastewater-treatment plants and 52,000 public and private water utilities sprinkled throughout the country. Such an organization could also facilitate better coordination between water and electric utilities. It could also serve as a clearinghouse for funding sources for infrastructure upgrades. Such an organization could create an ecosystem of utilities, organizations, and regulatory agencies supporting a common goal.

Six: Data Collection and New Metrics

In order to design, evaluate, and prioritize efficiency programs, new metrics are needed that calculate the water and energy embedded in the water cycle. Resource planning tools and models are being developed,[71] and water-supply and -consumption data are being collected. However, increased data collection and development of new modeling techniques are warranted. This is an appropriate role for the federal government, and adequate funding by Congress should be provided.

Much work has already been done to outline the data gaps. The Sandia roadmap report lays out specific data-collection needs, most of which revolve around the need to improve the collection and integration of water-supply availability data with energy-planning data at the granular, local level. The report concludes with the following ongoing needs:

- Develop, test, and commercialize new water-supply monitoring and characterization technologies.
- Improve and expand the national water resources

database.

- Develop a model framework for integrated energy and water planning that takes regional climate forecasts into account, along with the local needs of commercial, industrial, residential, and agricultural demands.
- Develop regional energy and water collaborative resources that will focus on planning pilot demonstration efforts.
- Develop and implement user-friendly decision-support tools for energy and water resource planning.
- Undertake national groundwater baseline studies and use parameters in each basin to protect the groundwater.[72]

It should be noted that not only do we need more data, but we also need better coordination between the federal agencies that collect energy and water data. The Energy Information Administration's (EIA) information on energy and power can be better correlated with the water data collected by the USGS.

Seven: Congress Can Remove Barriers to Private-Sector Infrastructure Financing

Current funding sources for water infrastructure upgrades include capital investments by investor-owned utilities (which reached $2 billion in 2011), $2.4 billion in federal funds in the Clean Water and Drinking Water State Revolving Funds, federal and state loan and grant programs, and municipal authority initiatives to raise customer rates and/or borrow funds.[73] As discussed in section 2, infrastructure needs will test municipalities' capabilities to raise such large amounts of funds. With the proper incentives and policy adjustments, funding sources could be available to meet investment requirements.

Private investment in infrastructure investment funds has been rapidly increasing. However, given that the vast majority of the water and sewer utilities are municipally owned, private-sector financing has been limited to bond finance markets. The key is to reduce the barriers and unleash private-sector capital to finance infrastructure upgrades through a variety of financing structures, utilizing tax-exempt facility bonds, taxable bonds, and equity funding.

There are proposals on the table to increase the availability of funds to the municipalities for required system upgrades.[74] Some advocate for the establishment of a clean water trust fund, similar to the highway or aviation trust funds. However, this proposal appears to lack public support, and faces opposition from the groups that would be taxed in order to put monies into the fund. Improved management of assets, by, for example, promoting water efficiency, full cost pricing of water, and/or expanding watershed approaches, in conjunction with green infrastructure initiatives, can certainly reduce utilities' costs and free up funds for upgrades. Alone, these measures will not make up for the need for much more investment in infrastructure.

There are several recommendations that would expand private infrastructure funding to the municipal sector. These measures would require congressional approval. The recommendations are:

- Remove the volume cap for private activity bonds[75, 76] that are placed on water- and wastewater investments; exempting water infrastructure will unleash capital.
- Amend the Clean Water Act to make private water companies eligible for state revolving fund loan programs.
- Change tax-exempt debt-reclamation policies when public municipalities sell or lease their systems to private companies in order to free up municipality resources for other pressing needs.[77]
- Piggyback on the successful commercial Property Assessed Clean Energy (PACE) program bonds that municipalities can offer to commercial and industrial property owners, and make efforts to expand this bond financing to the property owners for water-conservation and water-reuse projects.[78]

Eight: Research and Development (R&D)

Just as stakeholders are important in the consideration of integrated energy and water resource management plans made by industry, so too should the state and federal government agencies consult with multiple stakeholders as they outline R&D programs that are funded by taxpayer dollars. The universities, national laboratories, and research associations must have a seat at the table during the R&D planning discussions.

With many diverse groups working on different aspects of the problems, some potentially at cross-purposes, the federal government could play a useful role in sponsoring a workshop. Such a workshop would gather stakeholders across all levels of government, and from the private sector, academia, national laboratories, and the public. This exercise could be a first step in prioritizing R&D programs, helping stakeholders agree on which groups would be responsible for which R&D need, all of which could lead to making sure that scarce R&D funds are used for the most pressing R&D needs.

In previous reports, the Council has identified the water-related R&D needs for the power and fuels sectors. These include:

- dry and hybrid cooling technologies;
- better understanding of climate variability and hydrological forecasting;
- transmission system improvements and management strategies to support integration of renewables into the electric grid;
- ways to reduce water for alternative fuels (such as biofuels) production;
- new technologies for alternative transportation fuels and a fuller understanding of the water impacts of biofuels, oil shale, coal to liquids, and hydrogen; and
- methods to use nontraditional water (such as brackish groundwater, seawater, produced water, or wastewater) for fuels extraction and processing, as well as for power-generation facilities.

The National Academy of Sciences identified fourteen water-reuse research priorities that span human health, public acceptance, environmental protection, and quality assurance.[79] A bipartisan group of senators—James Inhofe (R-Oklahoma), Barbara Boxer (D-California), and Ben Cardin (D-Maryland)—have proposed that the United States restart a federally funded program that established fifty-four water-research institutes.[80] The program had authorized funding for applied water-supply research grant funding, but it lapsed in FY 2011.

Participants at the workshop expressed the need for several specific R&D activities as shown in Table 5.

Nine: Support Organizations Solving Energy Water Nexus (EWN) Issues

The Atlantic Council's Water and Watts workshop provided a good forum for a wide variety of stakeholders to provide information and policy recommendations. The Council's goal was to bring their efforts to the public's and policymakers' attention. It's no surprise that there are a myriad of dialogues going on across the United States, and the efforts of the sponsoring organizations warrant support from industry, government agencies, and individuals.[81]

The workshop highlighted the efforts of several key organizations and initiatives, including:

- The Alliance for Water Efficiency has teamed up with the American Council for an Energy-Efficient Economy

Table 5: Water-Sector R&D Needs to Improve Energy and Water Efficiency

R&D Needs for the Water Sector	
Improve advanced treatment technologies such as ultraviolet disinfection, ozone, forward osmosis and membrane technologies	Undertake additional research to develop energy-efficient desalination technologies
Research the opportunities for water reuse technologies	Work on forecasting hydrologic changes at a granular level and how predicted changes will match up against predicted energy and water demands at the watershed/aquifer level
Develop a comprehensive water sector climate change research strategy	Create a modeling framework that includes economic, environmental, water, and policy or regulatory constraints that can feed into integrated management plans
Increase data collections and expand types of data collected	Identification of opportunities for reuse of produced water and on water reuse technologies that use less energy than current desalination and reverse osmosis technologies.

(ACEEE) to identify the major research, program, and policy needs surrounding the EWN. It established a forum for the creation of a long-term energy and water community and published a blueprint for action.[82] There are four joint working groups on codes, standards, and tax incentives; water utility disincentives; energy- and water-saving programs; and research on EWN issues that are hard at work in 2012.

- In 1997, the Alliance to Save Energy launched the international WATERGY program to save both energy and water. It helped more than a hundred cities globally, from the Bahamas to South Africa to the Ukraine. It kicked off a US program in 2010 in Bucks County, Pennsylvania, which could be replicated in over a thousand similar large US systems.[83]
- The Clean Water America Alliance provides a forum, like the Urban Water Sustainability Council, for national dialogues with industry leaders, and it develops water-sustainability principles upon which national policy can be built. It also offers the US Water Prize, helping to encourage best practices and publicize success stories.
- Sandia National Laboratories has an established program to evaluate water-energy-agriculture challenges both in the United States and abroad. It spearheaded the development of an energy water nexus roadmap in 2007, and is a major partner in the development of the Western and Texas Interconnections.[84] Sandia has produced multiple models that evaluate the energy, water, and land needs in specific water basins across the United States.
- Water Citizen is launching Water Citizen News, which will be a free, subscriber-based news source for water-related news, features, and entertainment.[85]

6. Concluding Observations

The United States is a water-rich country. However, water supplies will face strains if not outright shortages in certain regions. Technologies and efficiency measures are available to address increasing demands for—and shortages of—water, but on their own cannot overcome the main barriers. Key barriers include the governance and fragmented nature of the water agencies themselves; the complex and overlapping federal and state government-oversight system; and the fact that consumers do not treat water as a commodity, but rather view it as a right that should be priced cheaply.

Energy demand to supply water and to treat wastewater is significant and will only increase. At water utilities, energy costs represent an increasing “bottom-line” expenditure. Utilities will increase on-site power generation with an emphasis on generation technologies that reduce costs, use less water, and increase the security of energy supplies at the site. Wastewater utilities have expanding opportunities to produce energy on-site through technologies such as anaerobic digesters that recover biogas for energy production. Energy-efficiency gains will be made with better pumps and tailored water end use.

The public is well aware of how to conserve energy and water in their homes and businesses, but often choose not to institute such measures. The public needs to know the importance of water itself, and that significant savings can be achieved by improving the water and energy efficiency in the water-supply infrastructure. Public education is key to unlocking efficiencies in the water cycle.

Not only will water demand increase alongside increasing population, but water supplies themselves are becoming more and more stressed. Hydrological changes are creating further supply uncertainties. As long as water remains underpriced and subsidized, conservation and system upgrades will be difficult to achieve.

Integrated resource management is essential for sustainable stewardship of US energy and water supplies. Such planning must consider population growth, land-use outlook, technological advances, and climate variability. More needs to be done to understand how to adapt to and mitigate the potential impacts of changing hydrologic regimes. Equally important is the involvement of local/regional stakeholders in the decision-making process.

Only by simultaneously pursuing the twin goals of sustainably using energy and water in every sector of the US economy will we bring the energy water nexus into balance. Sustainable solutions require a holistic approach, with integrated planning of both water and energy systems, as well as how these solutions interact with and impact water for agriculture. In fact, it is increasingly said that the energy water nexus should more properly be described as the energy-water-agriculture nexus. Further discussion is warranted on incorporating agriculture’s demands into the integrated management strategies for sustainable energy and water resources.

The energy and water industries are slowly coming together to talk about nexus challenges and what they can do together to find mutually beneficial solutions. Continued discussion is warranted. All industry stakeholders must intensely collaborate, but government engagement and leadership are required as well.

Without waiting for a crisis to push the energy and water industries toward a collaborative solution, and in the absence of agreement at the federal government level on a US energy policy, the private sector will have to take the lead in developing and integrating water and energy conservation, production, and management strategies.

The workshop, however, pointed out that those current solutions may not be "enough," and may in fact just shift the problem rather than solving it (i.e., from the energy or water sectors to the agriculture sector). Nonlinear, transformational solutions such as significant demand reductions (for energy, water, and agricultural products) may need to be considered.

There is a global dimension to the energy water nexus issue. However, solutions must be tailored to regional needs, and US industry can play a significant role in helping other countries tackle their energy water nexus problems. They have developed tools to provide clean drinking water and water suitable for agriculture with lower/renewable energy requirements. Low energy and net zero energy and water-treatment technologies being developed by the US Army can also provide concrete examples for successful strategies on the global stage.

Sustainable energy and water policies and programs require a new paradigm—one based on water becoming invaluable, not invisible. This paradigm will be supported by:

- realistic efficiency, conservation, and reuse strategies;
- policy and funding mechanisms that lead to a more-effective water resource supply;
- holistic/integrated planning between water and energy industries;
- using more clean technologies;
- leveraged partnerships;
- public acceptance of infrastructure investment and conservation measures;
- federal government efforts to craft a national energy strategy policy framework; and
- private-sector leadership.

Ultimately, the new paradigm of invaluable, not invisible water will augment US national security, job creation, and the competitiveness of the economy.

OCTOBER 2012

ATLANTIC COUNCIL

Water and Watts: Potential to Save Energy and Water in the Municipal, Industrial, and Commercial Sectors

June 19, 2012 • Washington, DC

INTRODUCTION

John R. Lyman, Director, Energy and Environment, Atlantic Council

CONGRESSIONAL PERSPECTIVES ON THE ENERGY AND WATER NEXUS

Elizabeth Fox, Professional Staff Member (Minority), Senate Environment and Public Works Committee

Lynn Abramson, Senior Legislative Assistant, Office of Senator Barbara Boxer (D-CA)

McKie Campbell, Minority Staff Director, Senate Energy and Natural Resources Committee

Patricia Beneke, Senior Counsel (Majority), Senate Energy and Natural Resources Committee and Former Assistant Secretary for Water and Science, Department of the Interior

Moderator: David Garman, Former Under Secretary, US Department of Energy, Principal, Decker, Garman, Sullivan and Associates, LLC

SETTING THE STAGE

Energy Intensity in the Water Treatment Cycle and Water Related Energy Use

Lorraine White, Water Energy Program Manager, GEI Consultants

The State of US Infrastructure

Tom Curtis, Deputy Executive Director, American Water Works Association

Transformational solutions for bridging the gap between projected future energy and water demand and projected future energy and water supply

Howard Passell, Senior Member of the Technical Staff, Sandia National Laboratories

Present Efforts and Overview of Key Issues

Mary Ann Dickinson, President and CEO, Alliance for Water Efficiency

Moderator: Nicole T. Carter, Congressional Research Service, US Library of Congress

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Harnessing Pump Technology to Improve Water and Energy Efficiency

Jes Munk Hansen, President, Grundfos North America

Energy Recovery in Waste Water and Bio Solids

Amit Pramanik, Senior Program Director, Water Environment Research Foundation

Energy and Water Efficiency in Municipal Waste Water and Water Supply

Kateri Callahan, President, Alliance to Save Energy

California's Energy-Water Nexus Programs

Shahid Chaudhry, Program Manager, Energy-Water Nexus, California Energy Commission

Moderator: Amanda Brock, CEO, Water Standard

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Policies to Incentivize Infrastructure Upgrades and Investment

William Rogers, Vice President and Treasurer, American Water

Proposed Water Infrastructure Finance and Innovation Authority

Tom Curtis, Deputy Executive Director, American Water Works Association

Moderator: Mark A. Limbaugh, Managing Partner, The Ferguson Group

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Status of Existing Codes and Emerging Strategies

Thomas Pape, Principal, Best Management Partners

Integrating Water Efficiency with Energy Efficiency in Standards

Steve Nadel, Executive Director, American Council for an Energy-Efficient Economy

EPA's Principles for an Energy Water Future

Sheila Frace, Acting Deputy Director, Office of Wastewater Management, US Environmental Protection Agency

Evolution of the Smart Grid Interoperability Panel as a Paradigm for Developing Water Standards

Dr. David Wollman, Deputy Director, Smart Grid and Cyber-Physical Systems Program and Manager, Smart Grid Standards and Research, National Institute of Standards and Technology

Moderator: Adam Carpenter, Regulatory Analyst, American Waterworks Association

PUBLIC EDUCATION AND OUTREACH

California Public Education Initiatives-ACWA's Campaigns, What has Worked and What Remains to be Done

Jennifer Persike, Director of Strategic Coordination and Public Affairs, Association of California Water Agencies

Public Education and Outreach Goals

Lorraine Loken, Senior Vice President, Clean Water America Alliance

Moderator: Paul Faeth, Senior Fellow, CNA Corporation

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General Richard L. Lawson, USAF (Ret.), Vice Chairman, Atlantic Council

How the US Army is Addressing the Energy and Water Nexus

Katherine Hammack, Assistant Secretary of the Army for Installations, Energy, and the Environment, US Army

Endnotes

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through the use of recycled water. The necessity and benefit of conjunctive water management are apparent when surface water and groundwater are hydraulically connected. Well planned conjunctive management can not only increase the reliability and the overall amount of water supply in a region, but also provide other benefits, such as flood management, environmental water use, and water quality improvement. Greater benefit can usually be achieved when it is applied to multiple regions or statewide." See www.waterplan.water.ca.gov/docs/cwpu2009/1009prf/v2ch08-conj_mgt_pf_09.pdf.

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Appendix A:

Atlantic Council Recommendations for Reaching a Sustainable Energy Water Nexus in both the Thermoelectric Power Sector and in the Extraction/Processing of Primary and Transportation Fuels

The Council recommends pursuing an agenda that will build a consensus on how the United States can address the energy and water nexus. Dealing with the nexus should be seen as an opportunity to simultaneously advance the United States' national economic and environmental health. Pursuing the following core recommendations will improve US energy and water policies:

- Publish the Energy-Water Science and Technology Research Roadmap that was prepared by Sandia National Laboratories at the direction of Congress in 2005, and update and expand the roadmap as necessary.
- Create a presidentially appointed task force to address and, most importantly, reduce, the federal, state, and local jurisdictional overlaps in regulating energy development, taking into account the role of agencies regulating the water supply.
- Improve coordination between the myriad federal agencies that deal with energy and water issues, and streamline the fractured congressional oversight of these agencies' policies and budgets.
- Develop a new paradigm of cooperation between the federal government's regulatory agencies and businesses on the forefront of US energy production.
- Decentralize water management to the watershed level with a goal of adopting aquifer compacts, and increase stakeholder participation in a collaborative decision-making process.
- Improve, modernize, and update the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) while recognizing that these laws have been successful in providing environmental protection and have provided models for other countries as well.
- Congress should direct and provide full funding for the USGS to collect and publish energy and water nexus data, including an understanding of how much water is available, ownership of water rights, the cost of purchasing water rights (where applicable), the stability of groundwater tables, and the feasibility of using substitute waters for freshwater supplies.
- Apply appropriate pricing and rate-design principles so that water is appropriately valued, moving away from the public's long-standing assumption that water should be, if not free, then cheap.
- Integrate climate-change impacts into water resource planning, especially in western and southwestern sectors of the United States.
- Similar to efforts to eke out as much energy savings as possible with energy-efficiency programs, focus as many resources as possible on water-demand reductions. A corollary recommendation is to pursue research and development of techniques that can reduce both the water and greenhouse-gas emissions footprint of the current energy-production infrastructure.
- Improve energy- and water-conservation opportunities through improvements to the water-delivery infrastructure and colocation of energy and water facilities.
- Rethink water supply through an array of initiatives that

can stretch and supplement US freshwater supplies, including:
  - harvesting rainwater;
  - increasing water storage using existing aquifers when water supplies are abundant, if it can be done efficiently from an energy point of view and without contamination problems; and
  - artificially recharge aquifers and expand the use of impaired waters, such as produced waters from oil and gas extraction and discharges from wastewater-treatment plants, to use in enhanced oil recovery (EOR) operations.
- Maximize and improve existing hydro resources and provide the energy industry with access to excess federal water supplies.
- Create a national/public dialogue using an innovative communications strategy to raise public awareness of the importance of the energy-water nexus, and why better coordination between government, the private sector, and stakeholders is necessary.
- Incentivize technology development to bring about:
  - development of new sources of water;
  - transformational changes in the way water is treated so that it can be recycled; and
  - improved agricultural practices to reduce the stress that agriculture (not just energy and fuels) place on limited water supplies.
- Recognize and advertise technology developments that can fundamentally change the energy industry's water challenges.
- Drive forward improved water and energy technologies and practices in the DOD and DOI.
- Advance efforts by the DOE to develop energy- and water-efficiency standards.
- Encourage stakeholders to pressure Congress and the administration to move forward with policy development and other needed changes.
- Adopt policies at the corporate board level to reduce companies' water footprint, and to use water as sustainably as possible.
- Find examples of good and bad practices and policies; for example, study the approaches other countries have followed in dealing with droughts (Australia); creating a centralized water policy and new institutional strategies for many member states (European Union); integrating regional approaches to water management (Russia); and addressing the pressures of moving from a developing to a developed economy (China).

Together, government institutions, companies, and stakeholders involved in the extraction and process of primary and transportation fuels must take steps to deal with the energy-water nexus. The Council also makes recommendations for better policies and standards across all of the fuel sectors.

For the renewable fuels sector:

- Reevaluate ethanol mandates in the renewable fuels standard.
- Develop biofuels policies that transition to the production of cellulosic biofuels and other water-friendly crops, incentivize the building of a commercial-scale production facility, and coordinates with agriculture policies which support farmers' use of water-wise crops.

For the coal and uranium mining sectors:

- Improve mining regulations by establishing better benchmarks upon which regulations are based, and which take into account the wide variability of streams' water quality throughout the United States.
- Encourage the mining industry to continue to develop best practices and improved material-handling methods.

For oil and gas production sectors:

- Designate a lead federal agency to take the responsibility on promulgating tough but fair fracking regulations. Whatever agency is chosen, it must improve its interface and develop partnerships with the companies involved in fracking.
- More research, transparency, and science-based development of fracking regulations is needed. This will lead to a better understanding of the practices, including the ability to pinpoint those that may lead to contamination, and distinguishing the actual fracking impacts from contaminants and chemicals naturally occurring in shale areas.
- Further study of the methane migration issue, full disclosure of fracking fluids, and banning the use of diesel fuel in fracking fluids will lead to greater public trust in unconventional oil and gas operations.

- Oil and gas industry must address the public's perception about the risks involved in unconventional drilling techniques, and make it a priority to gain public trust in its operation.
- Unconventional oil and gas operators must drive the push for—and integrate into operations—innovative technologies to improve well integrity; alternative well-stimulation techniques that do not use water; mobile filtration units to clean produced waters, and fracking fluids that return to the surface; replacing on-site diesel engines with gas engines to reduce the life-cycle water profile; use GPS to move trucks around more intelligently; and to reduce water needs to clean trucks and transportation routes.