

**Collaborative Water Risk Management: Guidelines for the Power Industry, Water Utility, and  
Regulator**

by

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## Abstract

Safe and adequate access to energy and water, the two natural resources driving the production of all other critical human needs, is key to economic development, public health, and military security. The availability of these two resources is threatened by the increase in demand and competing interests for their supply. Water resources are critical to energy production while energy resources are necessary for safe deployment and allocation of water. The constraints imposed by such reliance are evident in the thermoelectric and water supply industries, which must procure water to ensure operation while complying with water quantity and quality regulations. Thermoelectric plants are responsible for almost 90% of the generation capacity and 41% of the freshwater withdrawals in the United States (Kenny, et al. 2009). Water suppliers are responsible for 13% of freshwater withdrawals while 75% of a municipalities cost to process and distribute water is spent on electricity (Sandia National Laboratory 2006).

This study discusses the current framework and pricing structure under which a power and water utility operate and focuses on the relationship between these utilities, in order to identify collaborative strategies that ease dependence on both resources. The research identifies the main roadblocks to effective management including impeded flow of information, inaccurate pricing models, and increasing stress to water resources. To address the aforementioned roadblocks, five recommendations are presented with case studies serving as reference points. This guideline proposes the implementation of accurate price signals, demand response measures, collaborative efficiency programs, alternative water sources, and alternative energy sources to ease water constraints. Recommendations are the result of extensive literature and data review, as well as interviews conducted with utilities, agencies, laboratories, research centers, and technology providers.

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## I. Purpose and Outline

The purpose of this study is to provide guidelines to the power industry, water utility, and regulator which may ease operational and regional dependence on scarce water resources. The energy and water nexus is broad with many variables that may be evaluated. This study focuses on the thermoelectric and water supply industries. The research identifies the current framework in which these utilities operate and the roadblocks to effective management of water resources. The study concludes by addressing the roadblocks with recommendations. The recommendations focus on collaborative approaches and use case studies as reference points.

## II. Background

### A. Water and Energy Nexus

The water and energy sectors are inextricably interdependent. Water resources are critical to the steam and condensation process in energy production while energy resources are necessary for the withdrawal, treatment, and delivery of water. Approximately 90% of the electricity in the United States (U.S.) is produced using thermally driven water-cooled generation systems, and as a result, power production is responsible for the majority of withdrawals in the U.S. (Dziegielewski and Bik 2006). The U.S. withdraws 410 billion gallons of water per day; the power sector accounts for 49% of this total and is responsible for extracting 41% of all freshwater withdrawals (Kenny, et al. 2009). Water suppliers withdraw 13% of all freshwater resources and spend approximately \$4 billion per year to treat water (Energy Star n.d.). Water suppliers' national annual electricity consumption is roughly 30 billion kilowatt hours (kWhs) and 7 billion kWhs for wastewater treatment facilities (ICF International 2008). Consequently, a family of four in the United States uses approximately 400 gallons of water per day directly and 600-1800 gallons of water per day indirectly through power plant withdrawals (Union of Concerned Scientists 2010).

#### 1. Water Suppliers

Water suppliers and wastewater treatment facilities have intensive energy requirements. 80% of community and 98% of non-community systems are served by groundwater which uses approximately 1,824 kWh/million gallons, 30% more than surface water. Though more water systems use groundwater, the majority of water produced by a water system comes from surface water (Carlson and

Walburger 2007) (ICF International 2008). Supplying water to end-users may take 700 KWh/million gallons for municipal groundwater pumping systems (Goldstein and Smith 2002). Wastewater treatment facilities are not any less dependent as they use 950-2000 KWh/million gallons in electricity (Goldstein and Smith 2002).

Water and wastewater treatment facilities require a number of complex processes to ensure that water is safe to drink or discharge. Surface water treatment involves the removal of contaminants, pre-oxidization to kill disease-carrying organisms, flocculation and coagulation of finer particles, second-stage disinfection, and distribution to customers via high pressure pumps. Most electricity consumption occurs during the distribution (pumping) of water to customers (12,055 KWh/day assuming a 10 million/gallon per day facility) followed by raw water pumping to the plant (1,205 KWh/day assuming a 10 million/gallon per day facility) (Goldstein and Smith 2002). The energy intensity requirement for pumping water varies based on elevation and in the case of groundwater, the type of well. Not surprisingly, groundwater wells require more energy than shallow wells (ICF International 2008).

There are four main types of wastewater treatment facilities, trickling filter, activated sludge, advanced wastewater treatment, and advanced wastewater treatment with nitrification (Goldstein and Smith 2002). In a trickling filter large materials are filtered, fine particles are removed using an aerated grit removal system, organic wastewater is passed through a substrate known as a trickling filter system, and the water is then chlorinated and discharged. The trickling filter supports bacteria growth which may consume organic material. The activating sludge facility uses a settling chamber to remove small particulates. The leftover sludge from this process is separated into solids and liquids. The solids are anaerobically digested to remove organic material, after which the remaining sludge is disposed of in a landfill or incinerated. Advanced wastewater treatment adds another layer of filtration to the active sludge process prior to discharging the waste. Some facilities also add bacteria to remove nitrogen from the system (Goldstein and Smith 2002).

## 2. Power Suppliers

Thermoelectric power plants differ by fuel, method of generation, and method of cooling. The most common types of fuel in the United States are coal, nuclear, and natural gas. However, they are not the only ones to use thermoelectric processes; solar thermal electric and waste incineration plants use them as well. The method of generation can be conventional steam, nuclear steam, or internal combustion. In



a combustion turbine, the fuel (usually natural gas) is burned directly in a turbine, eliminating the need for cooling water to condense the steam (ICF International 2008). However, thermal power uses steam based generation which follows the Rankine Cycle (or Carnot Cycle). The Rankine Cycle uses water in a closed loop to convert heat into work.

The majority of U.S. power production comes from thermally-driven generation systems. The thermoelectric process involves heating water until it turns to steam and then using the steam to spin a turbine, which is connected to an electrical generator that converts the mechanical energy into electricity. After this is completed, the steam passes through cool tubes which condense the steam back to water (Centre for Energy n.d.). Alternatively, combined cycle uses natural gas in a combustion turbine to generate electricity and then utilizes the exhaust heat from the turbine to produce steam; thus, using cooling water in only a segment of operations. Due to greater efficiency gains, combined cycle plants have seen an increase in investment.

Power plants withdraw 99% of their water from surface water bodies (Kenny, et al. 2009). The main uses of water in these plants are blow-down, make-up, and cooling. Blow-down water is used in cooling towers and evaporative condensers to remove impurities and sediments which may corrode equipment (The Environmental Resource Center for Higher Education n.d.). Makeup water is pure water (thus not corrosive) which is mixed in with the recirculating condensate (feed water) to be used in boilers to create steam. Cooling water is used to cool the system so that the steam condenses back to water. The heat removed from this process must then be returned to the air or a water body.

The cooling process may be completed through a once-through, recirculating, or dry cooling system. In a once-through cooling system, the water is discharged to a water body after running through the condenser. The benefit of this process is a higher efficiency level near cool water bodies and a lower consumption rate. The disadvantage is that the high temperatures discharged to the water body may exceed thermal discharge limits. In a recirculating system, the droplets from the updraft of air in a cooling tower cool the water which then condenses to liquid form. The advantage of the recirculating system is the ability to site the plant far from a water body and its minimal withdrawal requirements. The disadvantage is the increased consumption rate which results from evaporative loss (3-5%) (World Nuclear Association 2011). The third type of system is dry cooling which only uses air to cool the system. Water use may be reduced by 90% with the utilization of this system (Wyman 2010); however, these systems have high costs and power consumption due to lower efficiency levels. It is for these reasons

that hybrid systems have entered the market. Wet/dry cooling systems use a water cooled condenser and an air cooled condenser; thus, using less water and power (GEA Heat Exchangers n.d.).

Input Resource		Product	
		Electricity	Serviceable Water
Water		<ul style="list-style-type: none"> <li>Ore Processing</li> <li>Refining</li> <li>Steam Generation</li> <li>Mining Operations</li> <li>Plant Operations</li> <li>Cooling</li> <li>Pollution Controls</li> <li>Coal and Slurry Pipelines</li> <li>Gas Storage Caverns</li> <li>Ash Handling</li> </ul>	
			<ul style="list-style-type: none"> <li>Pumps</li> <li>Treatment</li> <li>Plant Operations</li> <li>Repair</li> <li>Delivery of Materials</li> <li>Backup Power Requirements</li> <li>Wastewater Treatment</li> </ul>

**Figure 1:** Energy and Water Nexus

Figure 1 is a representation of the processes requiring water in energy production and energy in water servicing. Though estimates of water use in power plants are dependent on the type of cooling method, and estimates of energy use in water facilities are dependent on efficiency of pump technology, on average it takes ½ kWh to provide 1000 gallons of drinkable water and 2 gallons of water to produce a kWh (LeChevallier and Zinkevich 2009). It should be noted that though it takes only 2 gallons to produce a kWh, 25 gallons must be withdrawn from the water source to produce that kWh (EPA 2011). The consumption rate is due to evaporative loss in cooling systems that recirculate water. The thermoelectric industry consumes 3.3% of freshwater and, though this is significantly lower than the withdrawal rate, the withdrawal places a great amount of stress on the ecological system (Solley and Perlman 1998).



## B. Stressors and Resulting Vulnerabilities

Attention to the energy-water nexus is vital because when any two resources are interdependent then any stressor on one resource will automatically stress the other resource. As a result, the strain on both resources is likely to be exponential, rather than linear. Recent increases to water flow variability and controversy over access to fuel sources have added a new level of risk to residents who are dependent on the resilience of electric and water utility systems. It is therefore critical to note that major threats arise from the lack of preparation. Furthermore, there are geopolitical issues which may result in increased tensions across states and international borders.

### 1. Climate

The General Accountability Office found in 2003 that under non-drought conditions, 36 states could expect water shortages while under drought conditions, 46 states could expect water shortages in the next ten years (Government Accountability Office 2003). Drought conditions may not only pose risks for water utilities withdrawing water from surface bodies but also for power plants. The Tennessee Valley Authority (TVA) was just one of many power suppliers forced to shut down generators and/or reactors due to water shortages (National Energy Technology Laboratory 2009). Similarly, France was down 7 to 15 percent in power capacity for 5 weeks after a drought in 2003 (Hightower and Goldstein n.d.).

Greater variability in climate will force a number of stressors on utilities including unpredictable patterns in runoff, increasing dependence on groundwater, and greater occurrences of flooding. Consequently, these issues will complicate planning for storage capacity or treatment costs, strain already depleting aquifers, and lead to saltwater intrusion and infrastructure impairment (Mehan 2007). Droughts would add additional costs to infrastructure improvement due to the expense of lowering intake structures. Las Vegas, for instance, is expected to spend \$700 million to build a lower intake structure to withdraw drinking water from Lake Mead (Leurig 2010).

Power plants discharge water at high temperatures and as a result, place stress on the aquatic system. According to Clean Water Act's section 402, power plants must attain a National Pollution Discharge Elimination System (NPDES) permit from their respective State in order to discharge water into a water source. To attain this permit, power plants cannot exceed the state's requirement for the receiving water body's temperature. In times when temperatures are escalating, this may prove to be a challenge as power plants must shut off their operations so as not to exceed the limit. If a power plant is unable

to meet its demand from generation it will have to resort to purchasing power on the spot market where prices may be 10 times the cost of generation (Leurig 2010). As shown in figure 2, Sandia National Laboratory identified some of the recent threats to thermal generation faced by power utilities in its 2006 report:

1. As a result of a 1999 drought, water-dependent industries along the Susquehanna reported difficulty getting sufficient water supplies to meet operational needs
2. Browns Ferry Nuclear Power Plant, part of the TVA complex on the Tennessee River, often experiences warm river flows, such that the temperature of the water at the plant's cooling intakes often approaches or exceeds the Alabama water quality criterion of 86 °F, nearly the plant's discharge limit of 90 °F
3. Low water on the Missouri River leads to high pumping energy, blocked screens, lower efficiency, load reduction, or shutdown at power plants.
4. Tennessee Governor imposed a moratorium in 2002 on the installation of new merchant power plants because of cooling constraints.
5. Georgia Power lost a bid to draw water from the Chattahoochee River for power plant cooling.
6. Arizona rejected permitting for a proposed power plant because of potential impact on a local aquifer.
7. A New York Energy plant was required to install a closed-cycle cooling water system to prevent fish deaths resulting from operation of its once-through cooling water system.
8. Southern States Energy Board member states cited water availability as a key factor in the permitting process for new merchant power plants.
9. South Dakota Governor called for a summit to discuss drought-induced low flows on the Missouri River and the impacts on irrigation, drinking-water systems, and power plants.
10. Washoe County, Nevada, residents expressed opposition to a proposed coal-fired power plant's planned water use.
11. Proposed coal-fired power plant on Lake Michigan (Wisconsin shore) strongly opposed by environmental groups because of potential effects of the facility's cooling-water-intake structures on the lake's aquatic life.
12. Hot discharge water from the Brayton Point coal plant on the Massachusetts/Rhode Island border cited by EPA as contributing to an 87 percent reduction in fin fish in Mt. Hope Bay; EPA mandates a 94 percent reduction in water withdrawal, replacing seawater cooling with freshwater cooling towers.
13. University of Texas researchers said power plants would have to curtail production if 20th century drought conditions recurred.
14. Idaho opposed two proposed power plants because of impact on aquifer.

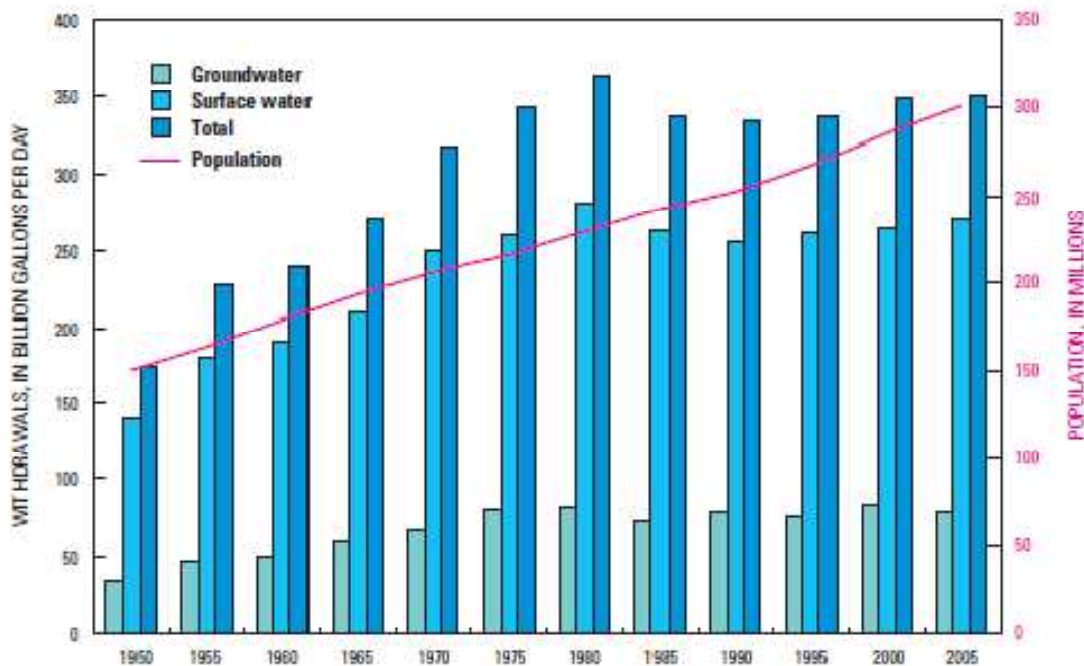
**Figure 2:** Power shutdowns due to water stress (Sandia National Laboratory 2006)

Furthermore, since work is generated while transferring heat in a heat engine, thermal efficiency is dependent on the difference between the input temperature and the ambient temperature. Therefore, regions with warm weather and droughts face increasing water stress as power utilities require greater amount of water to make-up for the lower efficiency levels caused by the small temperature differential

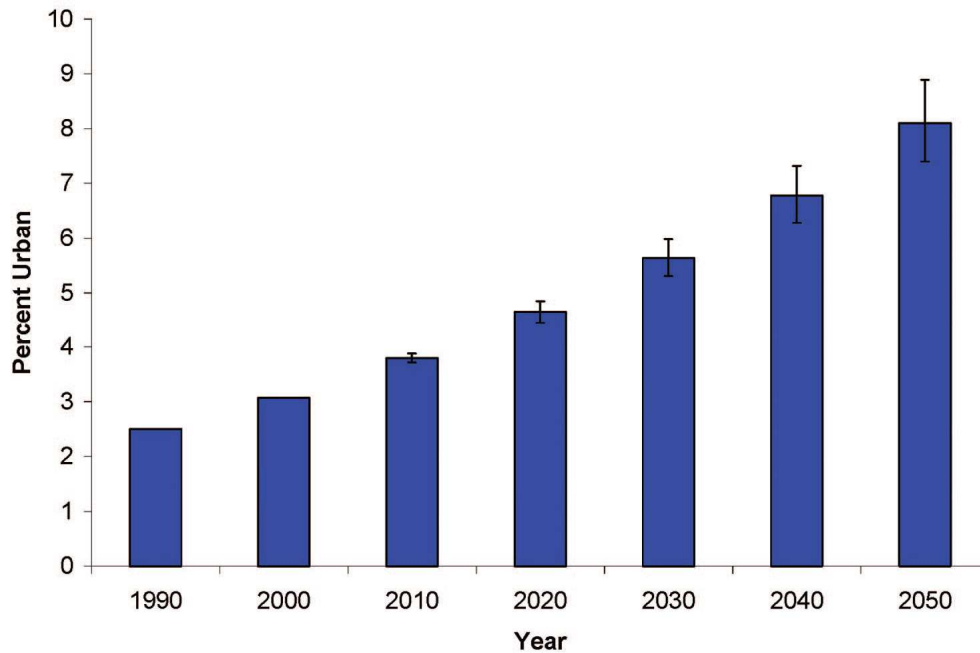
(World Nuclear Association 2011). Coal and nuclear use more water due to lower efficiency levels and in the case of nuclear, due to temperature constraints placed on plants to ensure safety.

## 2. Demand

The U.S. population is growing at a rate of 1%, instigating an increase in demand for water and energy resources (Central Intelligence Agency 2011). As shown in figure 3, the rising trend in population is matched with a rising trend in freshwater withdrawals. Roughly 3% of electricity consumption in the U.S. is attributed water utilities; however, one quarter to one-half of electricity used by many cities is consumed by the water sector (Lawrence Berkeley National Laboratory n.d.). This is a worrisome strain because as seen in figure 4, urban land is projected to triple in the next few decades (Nowak and Walton 2005).



**Figure 3:** Water trends (Kenny, et al. 2009)



**Figure 4:** Urban growth ( (Nowak and Walton 2005)

Under the current energy mix, increasing demand for energy will result in greater power generation at facilities, which will increase not only the assumed cooling, make-up, and boiler water requirements, but also forced evaporation. Forced evaporation occurs when water is heated above ambient temperature resulting in greater evaporative loss than occurs under normal conditions. A 500 megawatt (MW) coal plant with once through cooling may use about 12 million gallons of water per hour (Feeley, et al. 2006). Though in a once-through cooling system, water is returned to the water source, the heat of that outflow will result in high forced evaporation loss. One study, estimated that the Asheville Steam Station in North Carolina loses at least 40 million gallons per month to forced evaporation (Morton 2010).

### 3. Infrastructure

The American Society of Civil Engineers (ASCE) rated U.S. water and wastewater infrastructure a D- in 2009, the same grade it received in 2005 (American Society of Civil Engineers n.d.). The society ranks infrastructure based on condition, performance, capacity, and pending investment. The ratings indicate that the U.S. has high leakage rates, risks of pipes breaking, and a lack of funding for maintenance and improvement. The energy infrastructure only rates slightly higher at a D+, indicating similar risk. One city representative commented that the city had water lines one hundred years old and since geospatial analysis was not in use at the time, the city only became aware of the age after it learned the lines were

below a row of oak trees and therefore, had to be older. This is a concern considering that though dependent on material, most water lines have a life expectancy of fifty years (City Business Manager 2011). Infrastructure is not maintained or improved because there are not enough funds to support the effort. One estimate notes that the U.S. requires over \$220 billion to update and expand the water treatment and delivery system in the next twenty years, and more than \$400 billion to meet electricity demand in the next 25 years (ICF International 2008).

#### 4. Competing Interests

Conflicts among industries and regions will begin to emerge due to competing interests for water resources. Figure 5 shows the many industries with a stake in fresh and ground water sources. In addition to sector conflicts, there exist border conflicts. This is most common in the western United States due to historically low supplies of freshwater. Figure 6 presents the rivers with multiple power plants and state’s withdrawing from each source (Energy Information Administration (EIA) collects survey data from power plants in its EIA-923 form). At times of water stress, these states will have conflicting interests with their neighbors.

Industry	% of Total Withdrawals
Thermoelectric	49
Irrigation	31
Public Supply	11
Industrial	4
Aquaculture	2
Mining	1
Domestic	1
Livestock	0.01

**Figure 5:** Water withdrawals by sector (Kenny, et al. 2009)

River	# of Power Plants	# of States	States
Colorado River	27	5	AZ, CA, CO, NV, TX
Mississippi River	71	10	AR, IA, IL, LA, MN, MO, MS, TN, VT, WI
Missouri River	39	7	IA, KS, MO, MT, ND, NE, SD
Ohio River	54	6	IL, IN, KY, OH, PA, WV
White River	12	6	AR, CO, IN, MO, WA, WI

**Figure 6:** Estimates from EIA, 2009

## 5. Foreign Ownership

Due to lack of infrastructure funding, there has been an increase of foreign investment in the U.S. water supply industry. American Waterworks (the German utility, RWE has maintained 25% stake after spinning off the subsidiary (Hoovers 2011)) acquired Citizens Water and San Jose Water, Philadelphia Suburban (largest shareholder is the French company Vivendi (Funding Universe n.d.)) acquired Consumers Water, and Kelda (a United Kingdom company) acquired Acquarian (Farkas Berkowitz and Company n.d.). The increase of foreign control of vital resources leaves the U.S. open to political risk.

### III. Method and Scope

#### A. Scope

Though the guideline is applicable to all regions, the intent of the research was to assist regions that have historically had ample water supply. Regions that have dealt with water scarcity in the past have made efforts to lower water dependence; however, regions that have not been forced to do so are dependent on systems that are water intensive. One example is North Carolina, where electricity is met by water intensive generation systems such as coal and nuclear. While on average the United States is 65% dependent on coal and nuclear systems (Energy Information Administration n.d.), North Carolina is 90% dependent (Neubauer, Vaidyanathan and Eldridge 2010).

#### B. Method

The study utilized extensive literature review to explore the current framework and case studies to use as reference points for recommendations; however, the research was grounded in data analysis and interviews. Approximately 30 interviews were conducted in the course of the study in order to ensure the identified roadblocks and recommendations were relevant to real-time scenarios and concerns. As shown in figure 7 interviews covered a range of regions, sectors, and functions.

<b>Region</b>	<b>Sector</b>	<b>Function</b>
California	National Laboratories	Senior Engineer
North Carolina	Research Institutes	Economist
Texas	Technology Providers	Policy Analyst
Florida	Investors	Chief Investment Officer
Colorado	City Departments	City Department Business Manager
New Mexico	Government Agencies	Technical Consultant
New York	Public Power Utilities	Utility Planning Director
	Public Water Utilities	Environmental Coordinator
	Private Power Utilities	Public Utilities Director
	Private Water Utilities	Water Resource Manager
	Power & Water Authorities	Director of Finance
		Assistant City Manager
		Company President
		Principle Civil Engineer
		Principle Regulatory Analyst

**Figure 7:** Range of coverage through interviews conducted between 04/09/10 and 03/30/11

Interviews were conducted to assess:

- level of power producers' involvement in managing water stress concerns
- level of regulatory and community involvement in managing water stress concerns
- level of water utilities involvement in managing water stress concerns
- techniques tested and applied to adapt to current environment
- prior research on this topic
- interest in various types of results
- funding environment, particularly from the water utility sector
- investment outlook on municipality assets
- water resource concerns

The literature review covered topics such as water allocation, drought management, water treatment technology, cooling tower technology, climate change, utility history and management, and power and water financing. In order to confirm numbers in external studies and grasp the implications of the study as expressed in the background section, data from the U.S. Geologic Survey (USGS) and the Energy Information Administration (EIA) was analyzed. A Survey on water rates was added to this analysis in order to test whether water prices were indicative of factors competing for or straining water resources.

### **C. Target Audience**

The project's target audience includes power-utility planners, water-utility planners, land-use planners, security analysts, state regulators, and federal regulators. The goal is to provide a number of options that may be supported and implemented by a city or utility. Considering that the allocation of water resources involves a number of stakeholders, the more parties well-versed in the roadblocks and opportunities of the energy-water nexus, the greater the probability of attaining reductions in water consumption.

## **IV. Current Framework**

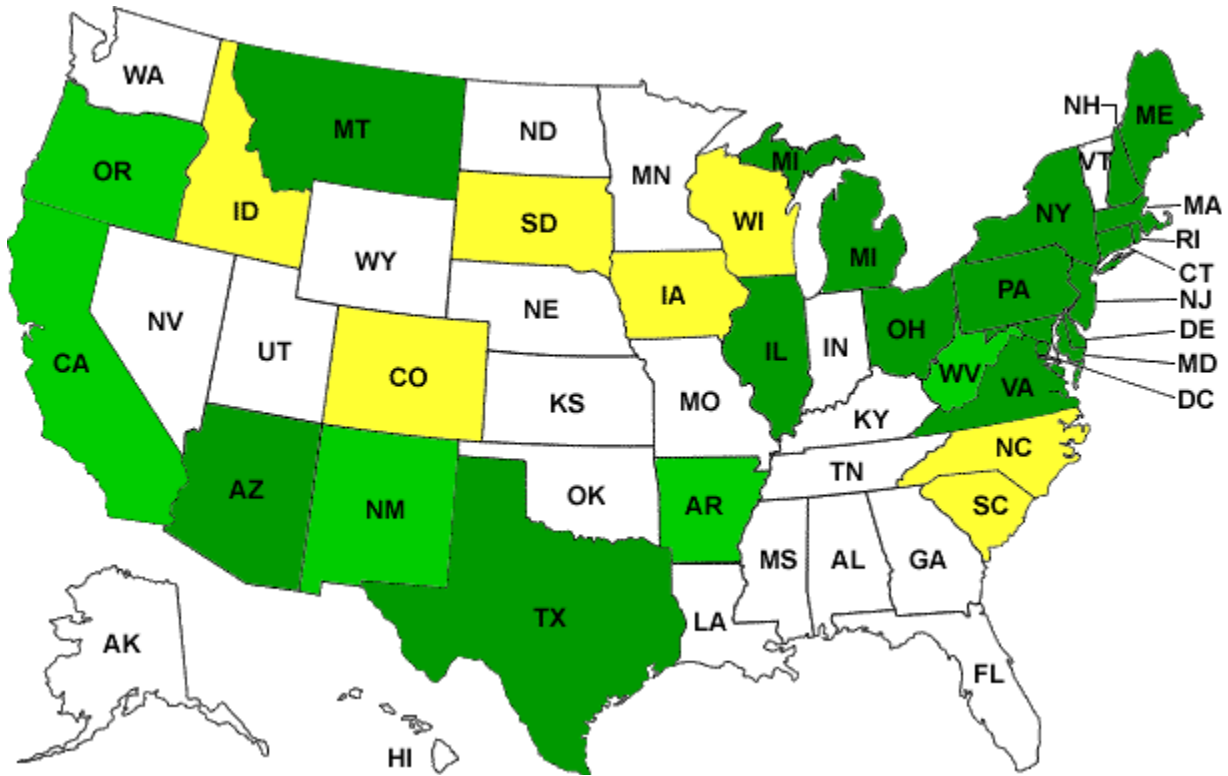
### **A. Regulatory Framework**

A utility provides a commodity and service that is considered to be critical to the general public and is therefore subject to regulatory oversight (Warwick 2002). There are two main regulatory structures for a utility, public and private. Each state differs on the type of utilities that exist within these categories which include district authorities, independent providers, home owner associations, non-profits, etc. A private/investor-owned utility is regulated at the state level by a regulatory commission which oversees rates and services. Within private companies, there may be holding companies, which are corporations with subsidiary utility operations. Holding companies have limits on the type of businesses they may engage in. The corporation itself is regulated at the federal level by the Securities and Exchange Commission. In 1935, Congress passed the Public Utility Holding Company Act (PUHCA) to give state regulatory commissions more control over the subsidiaries in their jurisdiction. On the other hand, a publicly owned utility is generally not regulated by a regulatory commission because it is assumed to have the customers (stakeholders) best interest in mind (Warwick 2002).



In the latter half of the 19<sup>th</sup> century there began a trend of municipalizing private water systems because of the lack in equitable distribution of services and infrastructure maintenance (Wolff and Palaniappan 2004). This trend had a strong impact as over 80% of Americans in the United States are now dependent on 53,000 state and municipal water suppliers (Leurig 2010). However, there has been an increase in water privatization in the last few years, with 16% of community water systems held by private companies (National Association of Water Companies n.d.). Power utilities on the other hand are dominated by the private sector. Forty-three million Americans in the United States are dependent on public power systems compared to the 259 million dependent on public water systems (Leurig 2010). Much of this difference is due to the movement to deregulate power industries in the 1990's, which resulted in the 1992 Energy Policy Act that opened transmission access to non-utility generators. Consequently, there has been a move away from public vertically-integrated monopolies to private decentralized systems where generation providers may be independent from transmission and distribution suppliers. Decentralization is spreading to some states much quicker than others as can be seen in figure 8.

Due to the important nature of water and its influence on every sector in the economy, a number of agencies are dedicated to reviewing and regulating the resource. There are 13 major federal agencies with an influence and/or stake in water resources including the Bureau of Reclamation, Environmental Protection Agency, Federal Energy Management Agency, Department of Health and Human Services, Department of Agriculture, Department of Homeland Security, National Oceanic and Atmospheric Administration, State Department, U.S. Army Corps of Engineers, and U.S. Geologic Survey (Mayberry 2010). At the same time there are over 125 state water and environment agencies (The Utility Connection n.d.).



**Figure 8:** Status of electricity deregulation per state (Warwick 2002)

**Yellow** -Completed studies of investor-owned utilities (power providers), not pursuing further action at this time.

**White** -Continuing to monitor restructuring investor-owned utilities (power providers), not pursuing further action now.

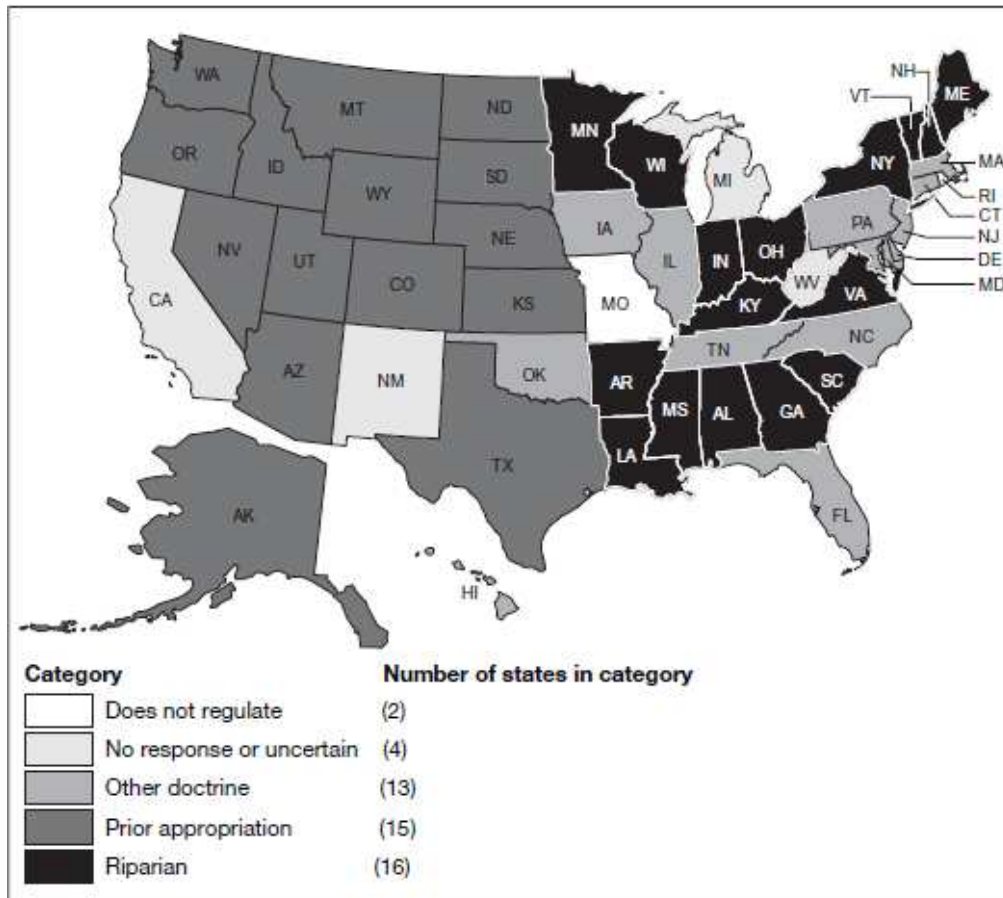
**Light Green** -Enacted legislation to implement investor-owned utility restructuring, but the transition not yet begun or suspended.

**Medium Green** -Transition to restructuring begun, are implementing competitive electric utility market for investor-owned utilities (includes Dist. of Columbia)

**Dark Green** -Have functioning competitive electric utility markets for investor-owned providers, allowing all customers' choice without stranded cost or other surcharges.

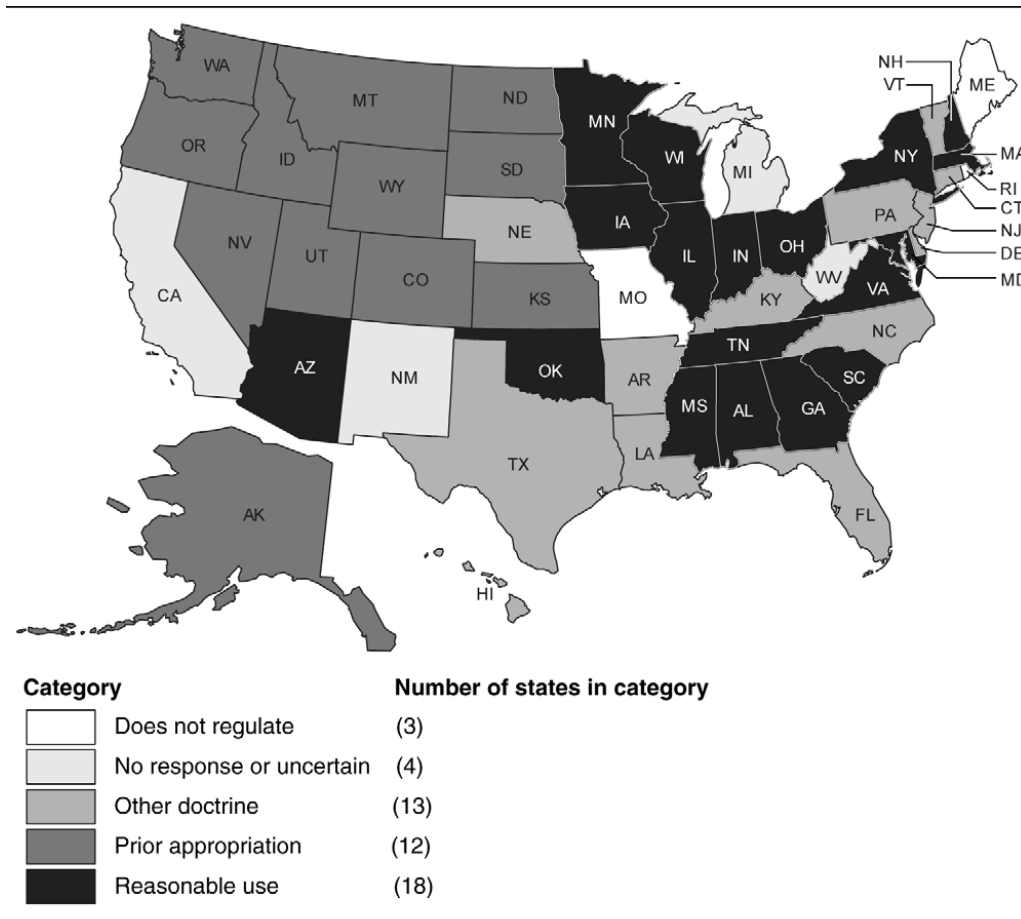
## B. Allocation of Water Resources

The commerce clause and property clause of the U.S. Constitution grant the Federal government authority to manage and regulate water resources that may affect interstate commerce or benefit federal property. States are able to manage and allocate water resources in their authority as long as it does not conflict with federal mandates. States generally use one of two main doctrines to allocate surface water, the riparian rights doctrine, common in states east of the Mississippi and the prior appropriations doctrine, common in states west of the Mississippi. Under the riparian doctrine, ownership of water resources is placed with those owning the land beside the water. While under the prior appropriation doctrine, the right is not linked to property rights but instead to those who used the water source for a beneficial purpose first. This doctrine is often called “first in time, first in right” because the first users of a certain flow of water keep the right as long as they continue using it beneficially while; the remaining goes to secondary users. In times of drought all users reduce their consumption proportionately (Governmentl Accountability Office 2003). Figure 9 portrays the water right breakdown by state.



**Figure 9:** State doctrine governing surface water allocation (Governmentl Accountability Office 2003)

Groundwater follows similar allocation right patterns. There is a further breakdown of riparian rights into absolute ownership (water beneath property) and the more common, correlative rights (rights divided by acreage owned) (Governmentl Accountability Office 2003). Some states use both sets of doctrines depending on locality. For example, California, Hawaii, Kansas, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, and Washington adhere to both doctrines. States have started to limit the amount of groundwater pumping by placing restrictions on distance between wells. Arizona has begun to manage its groundwater flow rate by establishing a Groundwater Management Act to reallocate rights and ensure a “safe yield,” to certify the withdrawal rate does not exceed the aquifer recharge rate (Cech 2010). Groundwater rights by state are shown in figure 10.



**Figure 10:** State doctrine governing ground water allocation (Governmentl Accountability Office 2003)

### C. Pricing Structure

Water prices are determined by transport from source to facility, treatment at facility, transport to user, demand, and any subsidies in place. The cost of transport may be expensive depending on the topography of the region, as elevated cities would be difficult to reach and require greater energy to pump water. Due to the energy intensive nature of pumping treated water to residents, electricity costs tend to weaken a utility's budget. The high electrical usage is compounded by the demand charge that industrial and commercial water customers are subject to pay.

A residential customer pays an electrical energy charge which covers the total energy used in the month. If a customer used 10KW for 5 hours then the usage rate is 50 kWhs. If the electrical rate is 11 cents, then the total bill is \$5.5. However, if the customer is a commercial or industrial customer like a water

utility, then the bill will include a demand charge. Demand is the maximum amount of electricity used at one time as measured by the meter each month. Most utilities record the highest 30 or 15-minute average on the meter for billing purposes. The rate for a demand charge tends to be much higher. Let's say the demand charge is \$6, then the customer will pay  $\$6 \times 10\text{KW} = \$60$  for demand plus the electrical charge of \$5.5 resulting in a total of \$65.5. The demand charge assists power utilities cover the cost of meeting peak load, which is the maximum amount of power required of the electric system at one time. However, it also adds to utility customers' financial burden.

In order to ensure a stable system there must be a balance between electricity consumption (demand) and generation; otherwise, the system will be strained and blackouts will occur. Peak demand is highest in the summer and winter when there is increasing use of air conditioners and heating units. As a result, many utilities have generating capacity on reserve in case they can't meet the total demand. This reserve is usually very expensive to operate; therefore putting strain on a power utility's balance sheet. According to the American Electric Reliability Corporation (AERC) peak demand is increasing and is expected to rise by 15% by 2018 (Orcutt 2010).

## **V. Roadblocks**

Utilities are faced with a number of financial and physical constraints for securing water resources and/or ensuring adequate supply of water to continue respective operations. This section identifies the roadblocks most often mentioned in literature, as well as in interviews with researchers and utility representatives. It should be noted that the roadblocks addressed in this section are not the only barriers utilities face but rather, the ones most commonly communicated during this study.

### **A. Information Traffic Jam**

A number of sources and studies have noted the lack of collaboration and integrative planning across power industries, water utilities, and state planners. For example, the University of Guelph's assessment of Minnesota's drought and water allocation planning, discussed the lack of interaction between counties and municipalities for water and land use organization (Pirie, de Loë and Kreutzwiser 2004). The concern for information-sharing is rooted in the nature of resource provider establishments. Research and analysis is often conducted by for-profit institutions which create a barrier for external parties attempting to use information outside the contract. One director noted that there is no

structure in place for information sharing (Representative from a National Laboratory 2010). A paper published by the Lawrence Berkeley National Laboratory (LBNL) examined the various interactions between the energy and water sectors and found four classes of relationships: large-scale government, grass-roots, third-party consultant, and Native American tribal (Goldstein, et al. 2008).

Relationships within large-scale government institutions were described in the LBNL study through the Tennessee Valley Authority (TVA), a federally-owned power company which not only provides energy but is also responsible for flood control and water quality. The study points to TVA's inability to gain from information sharing due to the nature of data security in large organizations. On the other hand, grass-roots relationships arise from short term needs; therefore, if water resources are needed, rather than using an integrative model to determine the sustainable source, power utilities reach out to neighboring industries on an ad-hoc basis (Goldstein, et al. 2008).

At times it's too difficult to secure these resources and organizations resort to hiring a third party. New York has a complicated structure in which most of their power system has been deregulated. Integrated planning is done by outside consultants, and as a result, is not accessible for data sharing. And while Native American Tribes own land with access to water resources essential to maintaining power supply in neighboring regions, they lack access to the power grid. This scenario has resulted in all parties and regions being unsatisfied, despite the number of tradeoff opportunities (Goldstein, et al. 2008).

Additionally, it was recognized that federal agencies were not collecting enough data in regards to power plants' use of water resources. According to a source from the Energy Information Administration Agency (EIA), Vlad Dorjets, the recent study published by the United States Government Accountability Office (GAO) on the nexus between energy and water has called for detailed data collection in regards to water use by electric power plants (Government Accountability Office 2009). As a result of this study, the EIA has updated its EIA-860 and EIA-923 surveys, which capture characteristics on power plants in the United States, including data on cooling system, cost, and power requirement (Dorjets 2011) . The Energy Information Administration updates include the GAO's recommendations, which advised adding nuclear and combined cycle generators to EIA's surveys and beginning data collection on alternative water sources. The report identifies the gap in data availability and the risks that arose after USGS's work on power plant water consumption was discontinued (Government Accountability Office 2009). The GAO recommends, and the USGS agrees, that USGS must continue its work on power plant withdrawals and supplement the research with consumption estimates.

## B. Water Gap

Rising water consumption rates are a concern for an increasing number of regions, as a water shortage would impact the most economically critical industries, including agriculture and energy. Increasing energy demands have put pressure on reservoirs, necessitating power plants to reach out to retail water agencies for resources rather than file for water rights with respective state water resource control boards (Government Accountability Office 2009). Water shortages will become more common due to increased climate variability and competing interests, such as water suppliers and agricultural users, requiring more water resources to meet population growth. Power utilities will also have to grapple with higher peak demand usage as population grows. In addition to the costs of securing additional water rights, power utilities will have to invest in generation capacity to ensure they are able to meet demand for the growing consumer base.

Water utilities are facing similar threats to financial and operational security due to the resources needed to maintain water levels in storage units. One example is Jordan Lake, a federal reservoir in North Carolina, west of Raleigh and south of Durham. The reservoir was built by the Army Corps of Engineers at a cost of \$146,300,000 of which the State of North Carolina paid a portion to secure water rights (U.S. Army Corps of Engineers n.d.). In order to recoup the payment, the state of North Carolina, charges utilities interested in withdrawing from the reservoir.

The Planning Director of Orange Water and Sewer Authority (OWASA) explained the additional costs to organizations trying to ensure that future water needs are met. OWASA purchased a 5% allocation at a level 2, a right to withdraw in the future. The 5% allocation gives OWASA the right to withdraw approximately 5 million/gallons per day. In order to secure this right, the authority pays the state \$12,000 which covers operations, maintenance, and interest. In the event the authority chooses to convert this right to a level 1, current use, OWASA will need to pay \$250,000 to cover its portion of the capital cost. Since the town of Cary (south of OWASA in Chatham County) operates Jordan Lake's treatment plant, the water would have to be delivered through Durham. A concern of OWASA's is that in order to withdraw at a level one, the authority would need permission from Chatham County (south of OWASA) and Durham County (east of OWASA). If any of these regions want to increase their allocation, they will need to prove that the increase is of a reasonable amount and purpose (Holland 2011). The limitations and additional cost of securing water resources may not only add strain to water



providers but brew conflicts between neighboring regions, even in states with historically ample water supply.

### C. Inaccurate Pricing

For many counties, the price for water resources is not indicative of supply and demand. This has resulted in liberal usages of water, gaps in infrastructure funding, and unrealistic price and supply expectations. The concern is that public sector utilities may be bound to inefficiencies that are feeding the water infrastructure deficit. In recent years, water quality regulations have added costs to compliance, which many water utilities are unprepared to absorb; as a result, there is a gap in maintenance funds. This means that decaying infrastructure subject to water losses will continue to contribute to water scarcity. One source from a water asset management team noted, “Water scarcity is a pricing problem and an energy opportunity (Water Investment Source 2010).”

The Ceres Report prepared by Water Asset Management in October 2010, presented the water scarcity problem as not only a supply risk but an insurance risk (Leurig 2010). The insurance risk may be attributed to the lack of transparency in the municipal bond market. In 2009, 10% of the \$ 3 trillion municipal bond market in daily trading volumes was attributed to public utilities that received top grades (AAA) from rating agencies such as Moody’s and Fitch (Leurig 2010). However, these rating agencies are excluding what may be considered a high risk category in their evaluation. The risk is attributed to what is common in a number of planning models, the assumption that water levels will be constant over time. This may not be a concern in regions with persistent rainfall; however, in water stressed states, the reduction in flows may translate to defaults. Default payments are no small sum considering public utilities represent billions of dollars in the bond market.

Not only do these ratings ignore physical constraints on water resources but they ignore regulatory risk as well. In the event that power producers are discharging at temperatures above the limit stated in their NPDES permit, production will have to be curtailed. Furthermore, it is likely that restrictions will be placed on water utility withdrawals after drought events. Figure 11 shows the results from Water Asset Management’s analysis of utilities’ financial and water risk scores (Leurig 2010). In order to invest in infrastructure, utilities will need a higher debt ratio (revenue inflow/debt outflow) to fund its infrastructure needs through debt. The higher the Water Rate Benchmark category, the more the region charges for water services. A high water charge equates to higher revenue payments for the utility. A high Baseline Water Risk score indicates high water demand and a lack of diversity in water

sources. As can be seen from Figure 11, cities such as Atlanta may be facing a strain from high demand on water coupled with the risk of sole dependence on Chattahoochee River, a reservoir operated by the Army Corps of Engineers. Additionally, the city does not have a particularly high debt ratio (Leurig 2010).

Utility	Baseline Water Risk Score	Credit Rating S&P / Fitch / Moody's (S)= Stable Outlook (N)= Negative Outlook	Projected Debt Ratio in 2014	Water Rate Benchmark
<b>Water Utilities</b>				
Los Angeles, CA	4,886	AA (S) / AA+ (S) / Aa2	1.88	33
Atlanta, GA	4,572	A (N) / A (S) / A1	1.16	43
Glendale, AZ	4,278	AA (S) / — / Aa3	1.48	28
Phoenix, AZ	4,233	AAA (S) / — / Aa2	2.33	34
Tarrant County, TX	1,419	AAA (S) / AA+ (S) / Aa1	0.92	28
Dallas, TX	736	AAA (S) / — / Aa1	1.50	8
<b>Electric Utilities</b>				
PowerSouth (AL)	2,548	A- (S) / A- (S) / A3	1.20	NA
Los Angeles, CA	1,480	AA- (S) / AA- (S) / Aa3	2.47	NA

**Figure 11:** Financial and water analysis (Leurig 2010)

### 1. Price Trending

In order to test whether counties were collecting enough revenue through water rates and whether rates were indicative of demand and competing interests, this study collected data from the USGS, EIA, and the Black & Veatch Consulting Survey on water rates (Kenny, et al. 2009) (U.S. Energy Information Administration n.d.) (Black & Veatch 2010). Black & Veatch surveyed 50 cities, the majority of which were county seats in their region. The cities were matched up with their counties and then matched to a Federal Information Processing Standard code (used by the USGS to aggregate data on water withdrawals and demand). Average electric rates in a state were assumed for each county. Figure 12 shows the results of the correlation estimates for varying factors with influence on water supplies and

water utility rates. Figure 13 presents the average water prices for residents using 7,500 gallons/month; however trends were checked for residents consuming 3,750 gallons/month and 15,000 gallons/month. Commercial customers were assumed to use 100,000 gallons/ month while, industrial customers were assumed to use 10 million gallons/month in the Black and Veatch survey.

The results all indicated that there was no correlation between the population served by a public water supply, the withdrawal requirements per person, the average state energy price, and water rates charged to residential, industrial, or commercial customers (correlation estimates are below the 0.7 mark, the point where a relationship may be interpreted). Similarly, figure 12 portrays the lack of a correlation between water prices, energy prices, electric generation, and withdrawals by competing users. The lack of a trend indicates that water rates are not accounting for factors significantly attributing to the probability of attaining water resources in the future.

	<i>Population Served by Public Water Supply</i>	<i>Public Water Supply Withdrawal per person</i>	<i>Avg State Energy Prices</i>	<i>Water \$ (Residential Customers)</i>	<i>Water \$ (Commercial Customers)</i>	<i>Water \$ (Industrial Customers)</i>
Population Served by Public Water Supply	1.00					
Public Supply Withdrawal per person	0.03	1.00				
Avg State Energy Prices	0.22	-0.07	1.00			
Water \$ (Residential Customers)	0.11	-0.04	0.10	1.00		
Water \$ (Commercial Customers)	0.15	-0.28	0.08	0.80	1.00	
Water \$ (Industrial Customers)	0.22	-0.23	0.13	0.67	0.92	1.00

**Figure 12:** Correlation between prices, demand, and withdrawal

	Avg State Energy Price	\$ Residential Water Price	Thermo Generation GWh	Thermo Withdrawals-Recirculating (Mgal/d)	Thermo Withdrawals-Once-Through (Mgal/d)	Industrial Self-Supplied Withdrawals (Mgal/d)	Acres Irrigated ('000s)	Mining Withdrawals (Mgal/d)
Avg State Energy Price	1							
\$ Residential Water Price	0.10	1						
Thermo Generation GWh	0.01	0.02	1					
Thermo Withdrawals-Recirculating (Mgal/d)	-0.19	-0.03	0.24	1				
Thermo Withdrawals-Once-Through (Mgal/d)	0.31	0.14	0.43	-0.09	1			
Industrial Self-Supplied Withdrawals (Mgal/d)	-0.06	-0.21	0.09	0.12	0.10	1		
Acres Irrigated ('000s)	0.16	0.13	0.04	-0.04	-0.07	-0.09	1	
Mining Withdrawals (Mgal/d)	0.10	0.07	0.01	-0.06	0.17	-0.09	0.06	1

**Figure 13:** Correlation between prices, generation, and withdrawals from competing users

If increasing rates may fund necessary improvements, then why haven't increases been implemented? Consumers are reluctant to pay high rates after having paid low prices for decades. Therefore without education, rate increases tend to result in political backlash. States with historically ample water supply are not accustomed to power outages and increasing water prices; however, in order to secure reliable electricity and clean drinking water, a sacrifice will have to be made.

Unfortunately, state representatives are not always willing to implement unpopular policies, especially around election time. Sonny Fredrick, mayor in the town of Ware Shoals in South Carolina cited water rate increases as one of the causes of his resignation from office in 2010 (Gwd Today 2010). On the other side of the country, the Mayor of Livingston, California, Daniel Varela, was ousted from office by a recall after passing a rate increase on water. The mayor's efforts to fund infrastructure improvements were not appreciated by residents who had not faced an increase in over a decade (Cooper 2010).

Political backlash such as this has made it difficult for public officials to implement increases that reflect the true resource value.

During interviews, a number of water utilities expressed the difficulty in running efficiency programs because there still exists the mindset that demand needs to increase for profits to grow (Utility Director and Environmental Coordinator 2011). Interestingly, these utilities tend to have lower rate increases which also increase profits. One city department's business manager noted the government's tendency to react to a crisis such as a drought rather than establish a preparatory approach. Another pattern with public utilities is the influence of city councils. A supportive council may be more willing to pass rate increases for necessary infrastructure projects (City Business Manager 2011). If rates do not increase, the only other way to fund infrastructure would be through debt, and according to one department, it's an unpopular move to take out debt to replace an old water line. Water lines have a greater chance of being replaced after they break and cause damage.

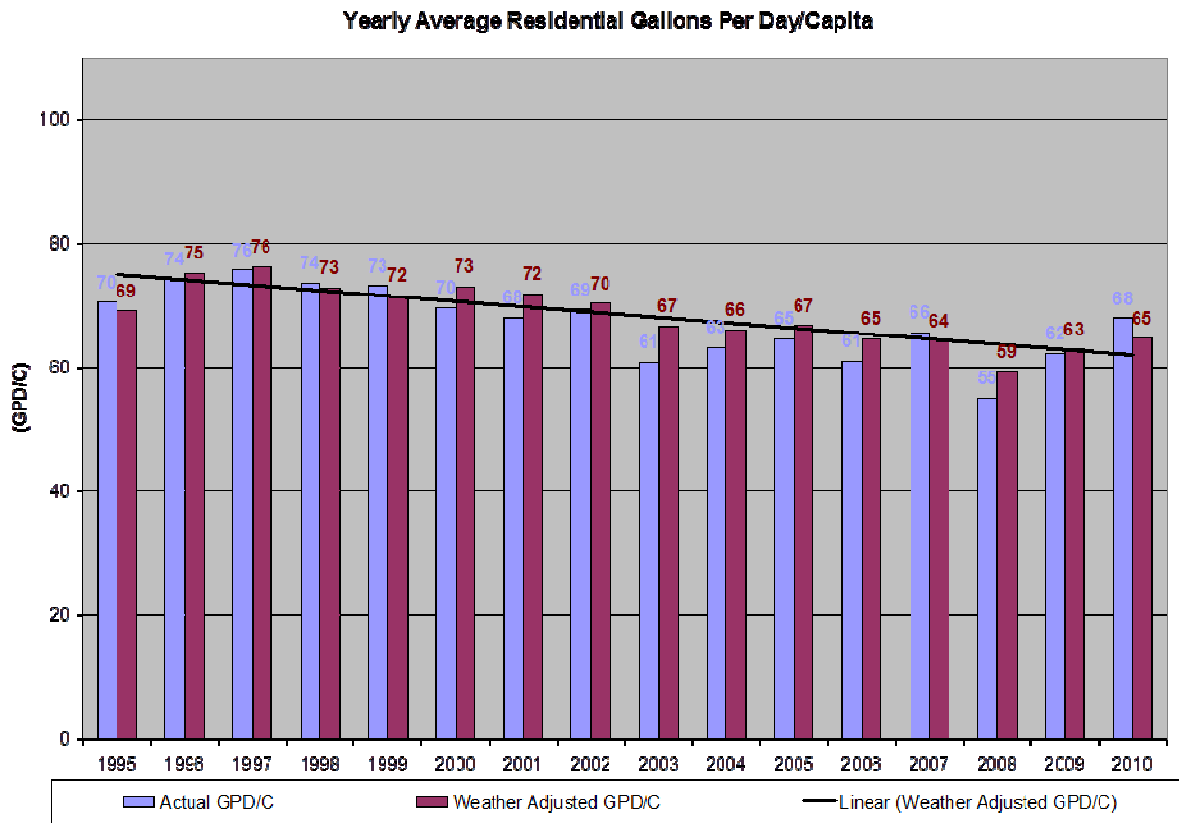
## **VI. Recommendations and Positive Models**

This study identified five actions the power industry, water utility, regulator and/or city planner may support by investing human and financial capital into research and development. It is important to note that not every utility can or needs to benefit from every recommendation; however, these recommendations were assessed and developed to help overcome the roadblocks addressed in the prior section

### **A. Price Signals**

True conservation cannot be achieved without accurate price signals. If consumers are not aware of the resource's shadow price (value of using additional units without making oneself worse off) then it is the industry's duty to analyze and distribute the information. A number of studies have proven the demand for water to be price inelastic, signifying that price increases though unpopular, will increase a water utility's revenue because the quantity of water consumed will stay the same. (Olmstead and Stavins 2007). These results indicate that price increases will keep the consumption high enough for the utility to still make money. However, during interviews multiple utilities mentioned the evident decline in consumption after rate increases were enacted, see figure 14. Therefore, these interviews indicate that consumers are price elastic and will lower consumption in response to a rate increase. As a result,

utilities are wary of investing in conservation education or efficiency programs as this would result in revenue shortfalls. Yet, these concerns are only grounded in short term outlooks because if conservation and efficiency is not implemented, then in the long run there will not be a resource to sell, as it will have been diminished or severely constrained. Therefore, regardless of elasticity estimates, it is in the best interest of the water supplier to ensure reductions in water use are made. According to recent interviews and studies, implementing a comprehensive pricing model is an effective measure to achieving this goal.



**Figure 14:** Decrease in consumption due to rate increases (City of Greensboro, NC)

It is a regulatory concern that utilities are issuing debt to fund operations without developing a detailed net revenue model to feed the cost structure necessary to pay off this debt. The ASCE estimated a \$2.2 trillion investment gap (American Society of Civil Engineers n.d.). It will not be possible to fill this gap if the regulatory structure constraining improvement is not evaluated. The federal government needs to show greater support to utilities with maximum transparency (accounting for security limitations) and high sustainability scores regardless of whether the utility is public or private.

Due to price increases being a highly politicized issue, it's necessary for regulators to assess public utility operations. The federal government provides a number of grants for water utilities to fund infrastructure improvements; however, despite these increases much of the infrastructure is in as dire a situation as it was years ago. One public utility director noted that part of the problem is that historically the goal of public utilities has been to provide cheap water to everyone (Utility Director and Environmental Coordinator 2011). However, only by making money can water be supplied. Public utilities should be encouraged to raise rates and compete for federal funding based on improvements. Furthermore, the cost structure should be derived from a model that includes revenue, cost, interest, maintenance capacity, and supply factors. Most importantly, in order for rate increases to be accepted by the public, educational programs need to be established.

## 1. Case Study-Prices

### a) *Orange Water and Sewer Authority (OWASA)*

Regional water stress is a growing concern for power utilities; however industries and regulators need to make decisions with a broader objective in mind. The power industry is not the only industry affected by water shortages; therefore, risk analysis and ensuing recommendations must include all sectors providing and consuming water resources. It's not enough to have efficient electric systems and energy conservative consumers rather, it's necessary to have sustainable systems from all resource providers. The challenge of incorporating new technology, dependable infrastructure, and conservation practices is tied to misleading water rates. Despite these challenges, a few utilities, such as OWASA, continue to charge the true shadow price to customers.

OWASA is a public, nonprofit authority serving approximately 80,000 residents in Carrboro- Chapel Hill, North Carolina. Drinking water for OWASA customers is withdrawn from Cane Creek and University Lake while, most non-drinking water is a product of treated reclaimed water (OWASA n.d.). Much of the information used in this case study was drawn from interviews with Ed Holland, OWASA's Planning Director.

OWASA, unlike many other utilities, focuses on water conservation through price signals reflective of supply and demand. In an interview with the planning director of OWASA, the reasons the utility has succeeded in charging a relatively high rate for water became clear. In October of 2010, OWASA raised rates by 9.25%, a spike which would have led to mass discontent in many regions across the United States; however, OWASA consumers were tolerant of the raise. The director expressed that this was a

function of effective education and communication. At no point are rate increases sprung on the consumer, instead the message is transferred through billing inserts, billing campaigns, news media, and public education.

The focus on education is made clear through OWASA's website which provides a "Water Watch" link. The link leads to easy to understand daily updates on the county's water resources including information on Cane Creek's capacity, rainfall predictions, drought shortage risk, and customer demand in MGD (OWASA n.d.). As a result, residents are aware of the motives behind rate increases and the restrictions on recreation in the creek. Moreover, conservation is further enforced through surcharges. Once the level of water in the reservoir drops below a predefined point, consumers receive a drought charge.

In addition to rate increases and surcharges, OSAWA sends price signals through tiered pricing. Every 1000 gallon unit increase in demand jumps the consumer to a different price rate. The planning director notes, "We have seen a 25% reduction in consumption from 8-9 years ago and this is partially due to drought awareness and increasing rates (Holland 2011)." To address the difficulties that low income residents face under increasing prices, OWASA developed the "Taste of Hope Program." Participants of the program agree to round their bill to the nearest whole dollar. The difference between their bill and their payment is then directed toward a low income home's bill. OWASA estimates this will cost consumers less than \$12 per year and assures none of the funds will be used to cover administrative expenses (OWASA n.d.)

On average, a resident may expect to pay \$80/month for his or her water and sewer rate, double what many in water stressed counties pay. This may sound like an exorbitant price; however, it's the true price of treating and providing water. According to Ed Holland, the utility uses a complex 15 year capital improvement plan which estimates revenue, sales, volume, and infrastructure needs. The objective of the tool is to provide an estimate for rates which is indicative of the cost to cover necessary infrastructure maintenance, facility operations, and transportation requirements. In the event that the model overestimates the rate increases, the balance is transferred to a "revenue stabilization reserve" which will offset any rate increases the following year. Similarly, if revenues are below the budget, OWASA is able to pull from the reserve prior to raising rates.



OWASA's planning director notes that the ease with which it is able to raise rates may be attributed to "being a water and sewer authority rather than a department of a local government which must compete with other public expenditures such as, education. The advantage is that we can operate like a business (Holland 2011)." The need for water utilities to operate like businesses has been one of the main messages of water asset management investors (Water Investment Source 2010). This is a systematic issue as securing necessary funding and providing incentives for continuous improvement are critical to recovering water levels.

## **B. Demand Response**

Demand response (DR) is a mechanism the power industry may use to balance consumption with supply, by engaging the retail sector in programs that allow it to participate in electricity markets (U.S. Department of Energy n.d.). Ideally, the retail sector would engage in dynamic DR where devices and controllers sense stress on the system and automatically shut off non-critical equipment. When the system has regained stability, the sensors signal the controllers to bring the equipment back up. In return, water utilities receive a payment for participating. The payment depends on the amount reduced and the time granted to warn the consumer utility of shut-down. In the case of water utilities, where demand is constant and there is little tolerance for water cutoffs, it is preferred that the power utility engages the water utilities in communication programs where advanced warning is issued, and it is in the utilities control to decrease energy use. In the event that water storage levels are low, the utility may choose to not take advantage of the demand response payment.

Power utilities need to work with water utilities to establish demand response programs. If the power industry does not reach out to the water sector, there will not be a way to bridge the information and knowledge gap, as water utilities are not in the business of selling electricity and therefore are not aware of these options. One demand response technology provider noted that one of the issues with initiating collaboration between the water and power sector is that each sector does not understand how the other operates (Neary 2011). Both sectors are filled with engineers and managers well-versed in their own fields; however, without a common understand of the other sector, it becomes difficult to identify opportunities.

By engaging in demand response programs, water utilities will open their structure to an additional revenue source. The extra funds may then be used to fund infrastructure improvements or offset rate

increases. Power utilities will contact water utilities during peak demand, thus lowering the strain on the electric system. The advantage of reducing the strain is a more secure system and the benefit of avoiding investing in additional generation capacity only to meet peak demand. Furthermore, if power utilities need less energy during peak time, which tends to occur most often in the summer, then power plants will withdraw less water during months with high evaporative loss (which increases with hotter temperatures).

The method of coping with moving water infrastructure off the grid will differ by region and utility. In states such as North Carolina or Florida, this may mean shifting to standby diesel generators; however, for states such as California, where the states' Air Resource Board places strict restrictions on air quality, it may mean recycled natural gas (produced when methane gas created by landfill waste is converted into gas). Areas currently utilizing diesel for standby generation should consider shifting to waste gas as water treatment plants are often sited near wastewater treatment plants, a convenient fuel source.

Areas with drastic elevation changes are able to make additional profit by providing ancillary services to the power system while participating in demand response. If a utility has reservoirs at two varying elevation points, it may use a pump and a small hydro turbine to generate electricity from the kinetic energy created when the water flows to a lower elevation. The utility is then able to let the upper reservoir drain during the day when prices are high and sell the generated power to the grid for the high price. It can then pump the water back to the upper reservoir at night when the prices are low. As a result, demand is lower during the day and there is additional capacity being provided to the power producers (Hayes 2011). At the same time, water utilities are making additional profit from the price differential paid to them for demand response, as well as the revenue from selling the power generated by their hydro turbines at a high price. In order for this to be successful, the water utility needs to have enough storage capacity to provide its customers with uninterrupted service and extra capacity to use as a "fuel."

Demand response is mostly being initiated in California, and as a result, new business models by external companies are being developed to take part in the opportunity. Since not every utility is able to decrease their load by a great amount and most power utilities do not have the capacity to reach out to a large number of retailers for load reductions, aggregators like Enernoc have found a niche in the market. Aggregators reach out to a number of retailers in the agricultural, industrial, and commercial sectors to take part in demand response programs. However, instead of a power utility calling all the

retailers signed up for reliability payments and requesting each one to reduce its load, the utility calls the aggregator and asks for a specific load reduction. To achieve the load reduction, the aggregator is able to use dynamic controls to shut off operations for non-essential equipment, more common with agriculture and call industrial and/or commercial customers with offers to shift load. In the case where utilities call industrial customers directly, the payment for reduction tends to be reflected in the energy bill, while in the case of aggregators, participants receive payments directly (Abreu 2011).

## 1. Case Studies- Demand Response

### a) *Florida Keys Aqueduct Authority (FKAA)*

The Florida Keys Aqueduct Authority was created by the State of Florida to serve potable water to over 45,000 customers (Florida Keys Aqueduct Authority 2010). The authority supplies this water via 130 mile transmission lines to the Florida Keys, located in Monroe County at the southern tip of the Florida peninsula (Florida Keys Aqueduct Authority 2010). Consequently, the authority uses a significant amount of energy on transmission and spends a large portion of its funds on power. Due to heavy reliance on energy, the authority has been investing in demand response and efficiency controls for some time. As the Executive Director of FKAA noted, “our transmission is slave to our demand (Reynolds 2011).”

At peak power demand, the authority switches to diesel generators which are able to sustain operations for weeks. On August 24, 1992, hurricane Andrew hit the J. Robert Dean Water Treatment Plant causing severe damage. Despite the damage, the facility was able to continue operating and supplying water on its standby generators for 21 days (Florida Keys Aqueduct Authority 2010). This capacity also allows the utility to cut its energy costs by switching to standby during peak hours.

In addition to its standby capabilities, the authority has contracted CH2M Hill to conduct a study on optimal efficiency opportunities. There is a distribution pump station every 30-40 miles to make up for friction losses; therefore, there is plenty of room to manage pressure and frequency to optimize operations (Reynolds 2011). The ability to employ supervisory control and data acquisition (SCADA) tools permits FKAA to monitor equipment at different settings in order to capture the most efficient and economical levels. SCADA monitoring tools are able to capture flow rate, energy price, friction losses, pressure, speed, and demand.

FKAA is looking at its operations dynamically because it has an extensive transmission network that opens up the utility to a number of vulnerabilities. Many utilities are not yet looking at demand

response in the manner FCAA is because they have not yet felt the same financial or physical stress from power costs. However, monitoring operations through real-time power cost analysis, allows utilities to identify process improvements with significant savings. These savings may come from reductions in wear and tear on equipment and/or the use of more efficient settings to run pump stations.

*b) Southern California Edison (SCE)*

Southern California Edison provides power (16.7% of which is renewable) to 14 million people in central, coastal, and southern California through 4,990 transmission and distribution circuits (Southern California Edison n.d.). The company has actively engaged consumers in demand response programs which manage peak demand and assist customers with energy payments. There are two general enrollment categories for a customer, price response programs and reliability programs. These programs offer discounts on the monthly bill for reducing load during peak demand. A demand bidding program provides credits to those signed up to reduce their load when called upon. In order to take advantage of the program, a customer must place a bid to reduce a load for two consecutive days. If the load is reduced with a day-ahead warning, then a payment of 50 cents/kWh for up to 50-200% of the bid is provided (Southern California Edison n.d.). If a load is reduced on the day of the option, then a 60 cent/kWh payment is made. In the case of reliability programs, such as a time-of-use base interruptible program, customers with over a 200 kWh load choose the amount of time needed to respond to an event (Southern California Edison 2010).

Mark Martinez, Manager of Demand Response Strategy and Planning for SCE, noted that in developing demand response prices, it's important to balance the price point and probability of curtailment because once the probability is decreased, the market to entry is easy (Martinez 2011). The most valuable customers to a power utility are those that are capable of shutting operations off immediately. These are usually larger customers because when dealing with smaller operations there is less ability to react in real-time. At the moment, the utility is noticing a lot of aluminum smelters opt into these programs because of the value service of loss principle, where it is more profitable for a firm to earn revenue from demand response than it is to run its regular operations (Martinez 2011). A water utilities ability to participate in these programs tends to depend on the season because when there is snow and runoff, water utilities have additional storage capacity, and therefore have the capacity to curtail.

*c) Pacific Gas & Electric (PG&E)*

Pacific Gas & Electric is a combination gas and electric utility that provides services to over 15 million people in northern and central California. The company uses 18,616 circuit miles of interconnected transmission lines (Pacific Gas and Electric n.d.) to deliver its service. As Ken Abreu, Principle Regulatory Analyst at PG&E points out, there are “a whole array of demand response programs that a water utility may use.” Most of these programs consist of the customer paying a fixed price to be on standby and ready to curtail. If the customer gets called, he receives an additional payment (Abreu 2011).” The payment is the differential between the expected load and the electric reading on the meter during peak demand. In California, water users are more active in demand response than other regions because of the energy intensive nature of providing water to consumers at varying elevation points.

As Mr. Abreu explained, the greatest demand response participation come from state water projects because they use a great deal of energy to move the water from reservoirs to urban areas. The second greatest is agriculture, particularly the pumping process during irrigation. They have become a popular source for curtailment since the increasing use of automated pumps and controls, which may be managed by the power sector during peak demand. The third largest users are wastewater treatment plants, which generally use waste gas as a fuel source in standby generation (Abreu 2011). Since California is looking to reach a 33% renewable standard by the year 2020, there is a great deal of attention being paid to demand response as a means to manage load because with an increase in intermittent generation, the system will need to have greater flexibility. As a result, these power utilities are looking for water utilities capable of investing in storage which may act as ancillary service providers (supports basic generating capacity). In the event that renewables are not producing enough to meet demand (may be due to climate), ancillary services will be increasingly desired. Though storage would not act as demand response, it would add demand response to the system (Abreu 2011).

Water utilities should not expect to be called often. If a water utility signs up for a demand response program, they are likely to be called 1 to 2 times a year with a request to curtail for 3 to 6 hours (varies based on contract) (Abreu 2011). The average electricity capacity bidding program may yield payments of \$50-\$70/MWh just to be on call. If the utility is called, then they may be paid \$50-\$500/MWh for reducing the load.

### C. Efficiency Program Collaboration

Water requires energy and vice versa, therefore incentives for collaborative conservation programs will save both industries money while easing the public's transition to a resource-constraint environment. Consumers that understand the relationship between the two resources are more likely to make productive tradeoffs and look for simultaneous solutions. At the same time, engaging the two interest groups in collaborative education projects will result in cost savings for both groups.

Regions which have not yet fully adapted to water stress due to historically high supplies may benefit greatly from efficiency programs. The American Council for an Energy-Efficient Economy (ACEEE) recommended a number of energy efficiency policy measures for consumers including building energy codes, combined heat and power, new federal appliance efficiency standards, and rural and agricultural initiatives. The study estimated "reductions in water withdrawals by 3,000 and 1,800 million gallons per day in 2025 in North and South Carolina respectively (Neubauer, Vaidyanathan and Eldridge 2010).

The study went on to examine water efficiency programs such as plumbing standards, water loss (leakage) reductions, blocks rates for water and sewer services, and efficient clothes washers. ACEEE estimated the total savings at 76.1 and 32.3 million gallons per day in 2025 in North Carolina and South Carolina. The electricity savings resulting from reduction in treatment and transport of water are 94.8 and 54.1 GWh in 2025 for North and South Carolina. To put these numbers in perspective, North Carolina withdrew 9,900 million gallons per day in 2005 for thermoelectric power production (Neubauer, Vaidyanathan and Eldridge 2010). This equates to 1-2% of energy use that may be cut with simple efficiency measures.

In order to enable consumers to fully understand and control their use of resources, smart meter capabilities need to be commercialized on a larger scale. Home Area Networks (HAN) would allow consumers to change settings on various appliances and automatically shut off energy intensive technology during peak hours. In-home displays for consumers and integrated network controls for the utility will not only save energy but educate consumers on the value of efficient appliances.

Utilities need to take a leading role in educating consumers on all alternatives and the interaction between each of these alternatives and the devices currently installed in the household. To sustain a holistic approach, interaction effects must be analyzed using a life-cycle approach; otherwise,

investment may be futile. For example, it would be counterproductive to install an energy monitor only to discover it consumes a significant portion of the household power.

In addition to consumer efficiency programs, it is advised that water utilities evaluate their operations as well. According to interviews conducted throughout the study, utilities that have contracted out external consultants to evaluate process and equipment efficiency identified a number of improvements. However, not all utilities may have the funds necessary to pay for such projects. Fortunately, there has been an increase in non-profits offering voluntary service from experts who conduct efficiency audits and provide recommendations. One example is the Waste Reduction and Technology Transfer (WRATT) Foundation which was incorporated in Alabama in 1993. WRATT provides assessments, seminars, and workshops on reducing operating costs (WRATT n.d.). Similarly, Waste Reduction Partners in North Carolina provides the expertise of retired engineers, scientists, and architects to assess facilities at no-cost and with full confidentiality (Waste Reduction Partners n.d.). One utility representative mentioned that the city council turned down the recommendation to utilize this service because of the assumption that outsiders would not know enough about the business, and because at the time of the recommendation the city was not facing a drought (City Business Manager 2011).

Depending on the region, electrical costs may range from 20 to 80 percent of a utility's operating budget, with regions such as California spending the majority of the state's funds to pump water (ICF International 2008). Therefore, any measures which may be used to lower energy costs will provide financial relief to the water sector. The City of Pleasantville, California realized savings of \$90,000 (34% of annual energy expense) 16 months after installing energy efficient pumps and motors (ICF International 2008). One cost saving measure that has been estimated to have energy savings of 50% is the conversion of coarse bubble diffusers to fine bubble diffusers (Environmental Dynamics, Inc. n.d.). One utility manager mentioned that this change is in his implementation plan because it was a recommendation made by an external consultant. Bubble diffusers are a pollution control technology used to aerate wastewater. However, since fine diffusers provide double the mass transfer of oxygen that coarse diffusers provide, they are significantly more efficient (Environmental Expert n.d.).

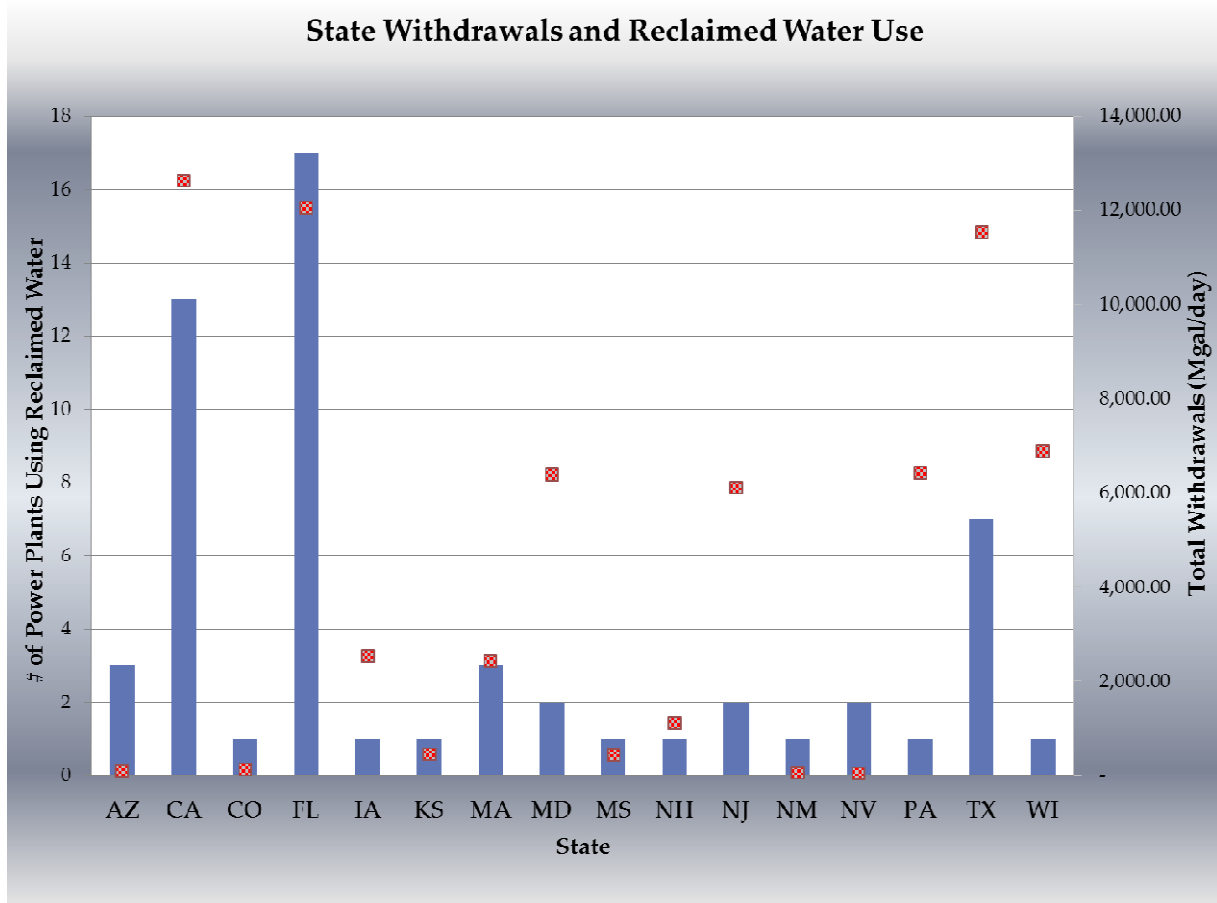
1. Case Study-Efficiency  
a) *East Bay Municipal Utility District*

East Bay Municipal Utility District (EBMUD) serves 1.3 million people in Contra Costa and Alameda counties in California. The utility provides wholesale and retail water from its two reservoirs on Mokelumne River, as well as wastewater collection and treatment (Contra Costa LAFCO 2008). EBMUD has origins in the private sector but it was absorbed into a public utility structure after the Municipal Utility District Act of 1921, which allowed for the creation of a public agency that could absorb public or private utilities and provide a number of utility services (Fauconnier n.d.). The utility, in an effort to recognize cost savings in its Special District 1 wastewater treatment plant, identified a number of improvements. These measures included cogeneration using waste methane, high efficiency effluent pumps and high-efficiency motors, added plastic balls to the vaporizer pit to prevent heat and evaporative loss, increased off-peak pumping, and replaced two small compressor units with one large unit (Energy, California n.d.). As a result, EBMUD recognized \$2,796,000 in annual savings and added energy capacity using cogeneration by 7.1 MW (Energy, California n.d.).

D. Alternative Water Supplies

When water scarcity is being discussed, it is in reference to freshwater resources. The public needs freshwater to drink and the power sector needs clean water that will not corrode or clog the equipment providing energy. The decreasing supply of freshwater resources has prompted a small number of utilities to invest in alternative water supplies, such as reclaimed water for cooling power plants. This has been unique to regions prone to water shortages and has not been implemented on a nation-wide scale. Considering that historically water stressed regions have make-up water requirements, it is expected that reclaimed water will be used by recirculating plants to dilute warm waters in the ponds or as blow-down for waters leaving the condenser. Dilution is necessary to lower the water temperature as warmer water is subject to increased evapotranspiration rates which exacerbate water shortages. As indicated by figure 15, the majority of power plants utilizing reclaimed water are located in CA, FL, and TX, regions which are no strangers to water stress. These states have invested in the infrastructure because they require large withdrawal rates due to growing populations and declining resources. These power utilities are often able to secure wastewater by negotiating contracts with water utilities.





**Figure 15:** Withdrawal rates for states with reclaimed water plants. Data from (Veil 2007) & (Kenny, et al. 2009)

The level of regulatory hurdles a municipal water treatment plant undergoes varies by state. Though there are no federal regulations directly pertaining to water reuse, the federal NPDES permit has water discharge requirements that mandate treatment plants use secondary treatment, which involves removing contaminants left over from primary treatment, typically by using bacteria to rid of organic matter (Siemens n.d.). In some states such as California, cooling water that “mists” out of the plant creates a plume and is therefore subject to more stringent tertiary treatment, such as additional filtration and disinfection (Veil 2007). The level of treatment and type of usage permissible in each state affects the level of investment in wastewater infrastructure. The increased investment is often followed by regulatory controls (Leurig 2010). An additional hurdle for utilities looking to provide reclaimed water is resident’s perception of the product. One utility representative noted that despite reclaimed water selling at 70% of the regular price, residents are slow to connect (Reynolds 2011).

1. Case Studies-Alternative Water Supplies

a) Orange Water and Sewer Authority (OWASA)

The majority of non-drinking water provided to OWASA customers is reclaimed water treated at the Mason Farm Wastewater Treatment Plant (OWASA n.d.). Following the drought of 2001 and 2002, the University of Chapel Hill (UNC) made the switch to reclaimed water for irrigation, flushing, landscaping, and cooling (for the steam plant providing distilled water to research labs) (NC Division of Water Resources n.d.). The University funded the necessary infrastructure needed to pipe the water from Mason Farm and now has the capacity to utilize 3 million gallons per day (MGD) (OWASA n.d.). The extent of UNC's use of reclaimed water can be seen in figure 16.

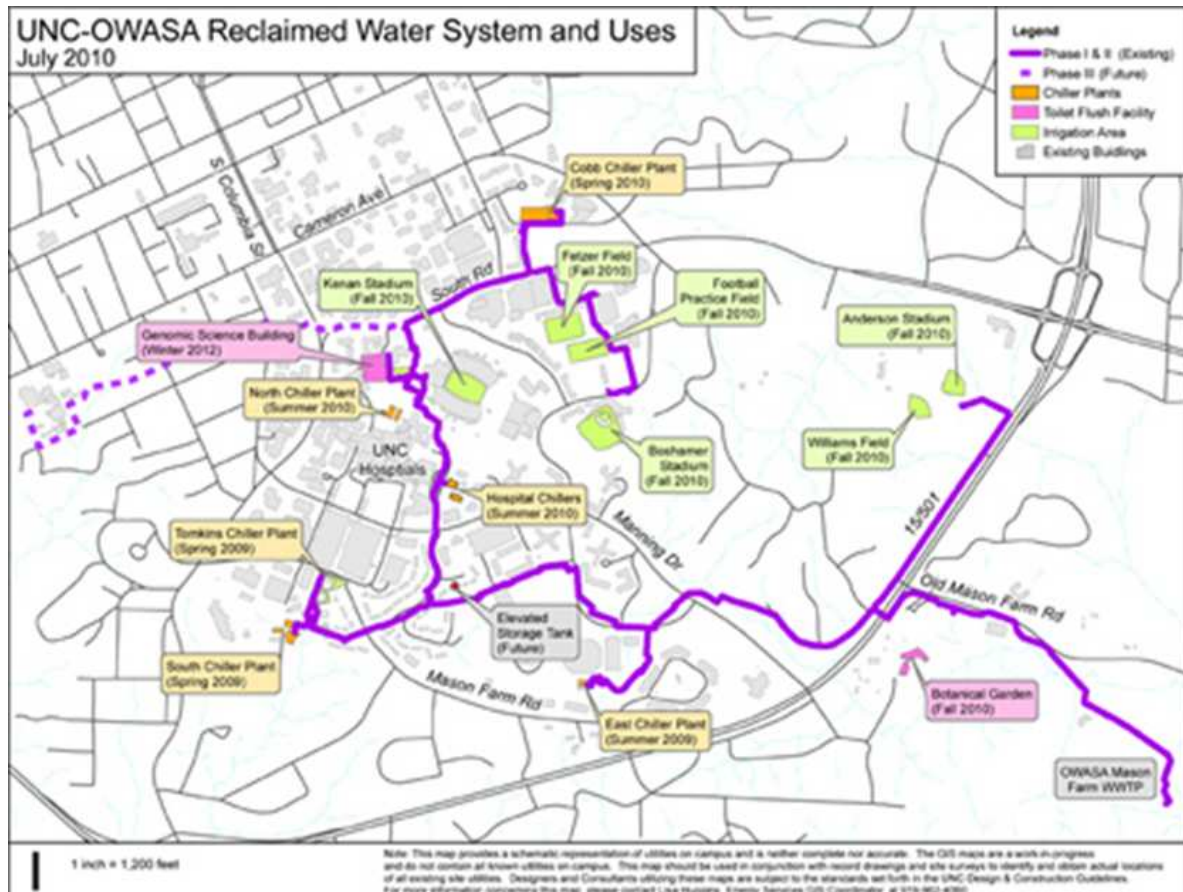


Figure 16: Map of reclaimed water system (OWASA n.d.)

*b) Arizona Power Service (APS)*

Some of the highest grade uranium ore in the United States is located in Arizona (Bills, et al. 2011); however, as rich as the state is in uranium, it's as poor in water. This is a major concern considering nuclear power plants utilize more water to make up for their lower efficiency levels. This is because thermal efficiency depends on the differential between the input temperature and the environment temperature. It is for this reason that many plants operate at higher efficiencies in the winter (World Nuclear Association 2011). Regions prone to warm weather and droughts tend to face greater water scarcity due to lower efficiency capability. The World nuclear association estimates that a plant running at "39% thermal efficiency will discharge about 24% less heat than one providing the same electrical output while running at 34% (World Nuclear Association 2011)." To put these numbers in perspective, a typical plant runs at 40% efficiency using coal, 60% using combined cycle turbines, and 34-36% using nuclear (World Nuclear Association 2011).

The majority of Arizona's surface water supply comes from the Colorado River through the Central Arizona Project (CAP). However, this supply is capricious considering the Colorado River supplies six other states (CA, NV, WY, UT, NM, CO) and has been subject to a number of droughts. Furthermore, CAP has junior priority rights indicating that in the case of a drought there may not be enough water to allocate to it (Central Arizona Project n.d.). Accordingly, alternative water sources for electric generation may be needed to manage operational risk.



**Figure 17:** Map of the Colorado River ( (Travel Blog n.d.)

APS owns the largest generating facility in the United States, the Palo Verde Nuclear Plant. The plant's three units are capable of producing 3,810 MW, and since it's sited in a desert climate, it utilizes wastewater to meet its cooling demands (Portland Cement Association n.d.). Palo Verde purchases wastewater from the City of Phoenix's municipal facilities and treats the water at its cooling facility. It is the only nuclear facility in the United States to utilize effluent for cooling towers (Arizona Power Service n.d.).

APS's Redhawk station, a combined cycle natural gas plant with a capacity of 530 MW purchases treated wastewater from Palo Verde to meet its own cooling needs (Arizona Power Service n.d.). This plant is a Zero Discharge Liquid (ZDL) plant, which indicates that no liquid is discharged to the outside environment. This requires a holistic approach to ensure water is treated and reused efficiently. The process includes a compressor-driven evaporator which receives high salinity blow-down water from the cooling towers and concentrates the brine. The product is a highly pure distillate which may be used in the cooling towers. The remaining salts are crystallized and dewatered (Veolia Environment n.d.).

The disadvantage of using wastewater is that it requires a greater amount of water for "blowdown," the water necessary in the cooling system to make up for the impurities left in the system post evaporation. Nevertheless, utilizing more wastewater will hedge against a number of drought and regulatory risks. Alternative water uses will need to be evaluated by regions with climates less extreme than Arizona's

because the cost of uncertainty may outweigh the cost of infrastructure. Extreme variability due to climate change may have statistically fat tails, demonstrating that the probability is not high but the consequences may be dire. Preparing for various levels of variability will illustrate which institutions will be ahead of the curve in the coming year and which will be struggling to catch-up.

*c) Calera*

In an ideal and sustainable environment, industries would have the option of reusing all the inputs and outputs in their processes. This would require complex and dynamic blueprints and a deep understanding of the duplicate interactions that occur in individual industries. The ability to site a facility that is able to provide power, treat water, and create products is not only profitable but risk averse.

Calera Corporation was founded in 2007 by Brent Constantz who was interested in easing the United States' dependence on imports for cement. Traditional cement production, as shown in figure18, contributes a significant portion to the nation's carbon dioxide emissions while the global cement industry accounts for 5% of the global anthropogenic CO<sub>2</sub> emissions (Worrell, et al. 2001). CO<sub>2</sub> is produced during the process's chemical transformation of calcium carbonates (Environmental Protection Agency 2011). Constantz hypothesized that carbonate cements could be made from seawater, and after running some tests, his team realized they needed to bubble carbon dioxide through the seawater. It was with this insight that Calera formed. The idea that rather than emit carbon dioxide through cement production, it's possible to consume the greenhouse gas was a stepping stone for integrative resource planning.

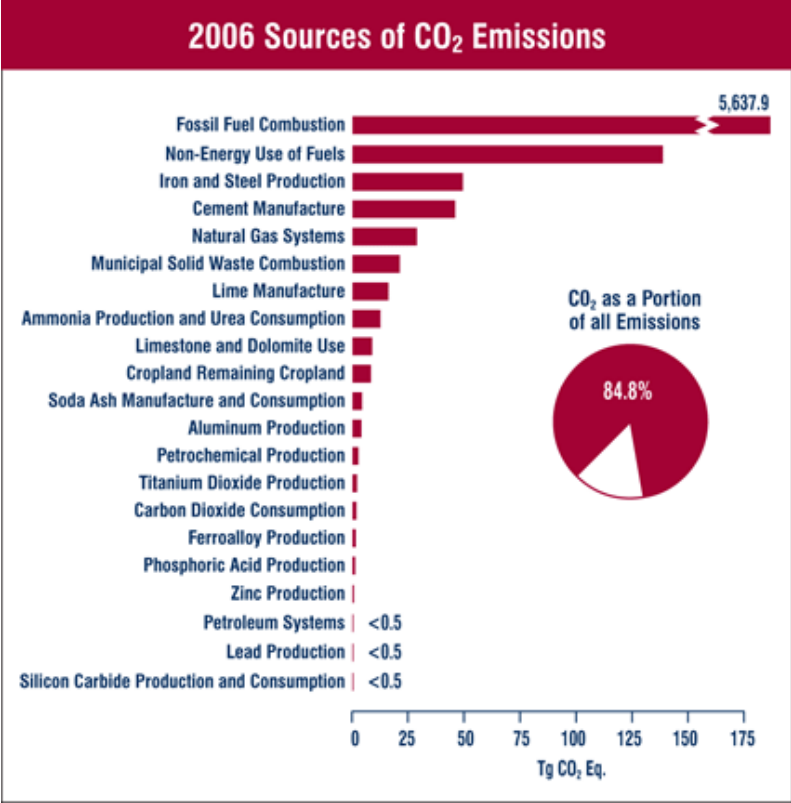


Figure 18: 2006 CO<sub>2</sub> emissions in the United States (Environmental Protection Agency 2011)

Calera built a pilot plant in Moss Landing, California across the street from Dynergy’s natural gas plant in order to capture the plant’s flue gas and reuse it in Calera’s material production process (Calera n.d.). Recent developments include plans to build Moss Landing Water, a desalinization plant to sell water to nearby water agencies. Constantz plans to utilize deep sea water for desalinization as it is less contaminated, thus taking stress off near shore seawater. Calera Corp is partnering with Desal America, which offers a number of water treatment systems, to develop the plant. The partnership will benefit from the resources each party brings to the table. Calera is already utilizing seawater pipes, and Desal already has permits for seawater intake and outflow (Johnson 2010).

The process is centered on the idea of capturing flue gases and converting it into useable products such as water or cement. Figure 19 portrays Calera’s sustainable reuse and production process. Outputs such as brine, wastewater, and fly ash are transformed to clean water and supplementary cementitious material (SCM). The pilot plant in Moss Landing produces five tons of SCM per day using the company’s

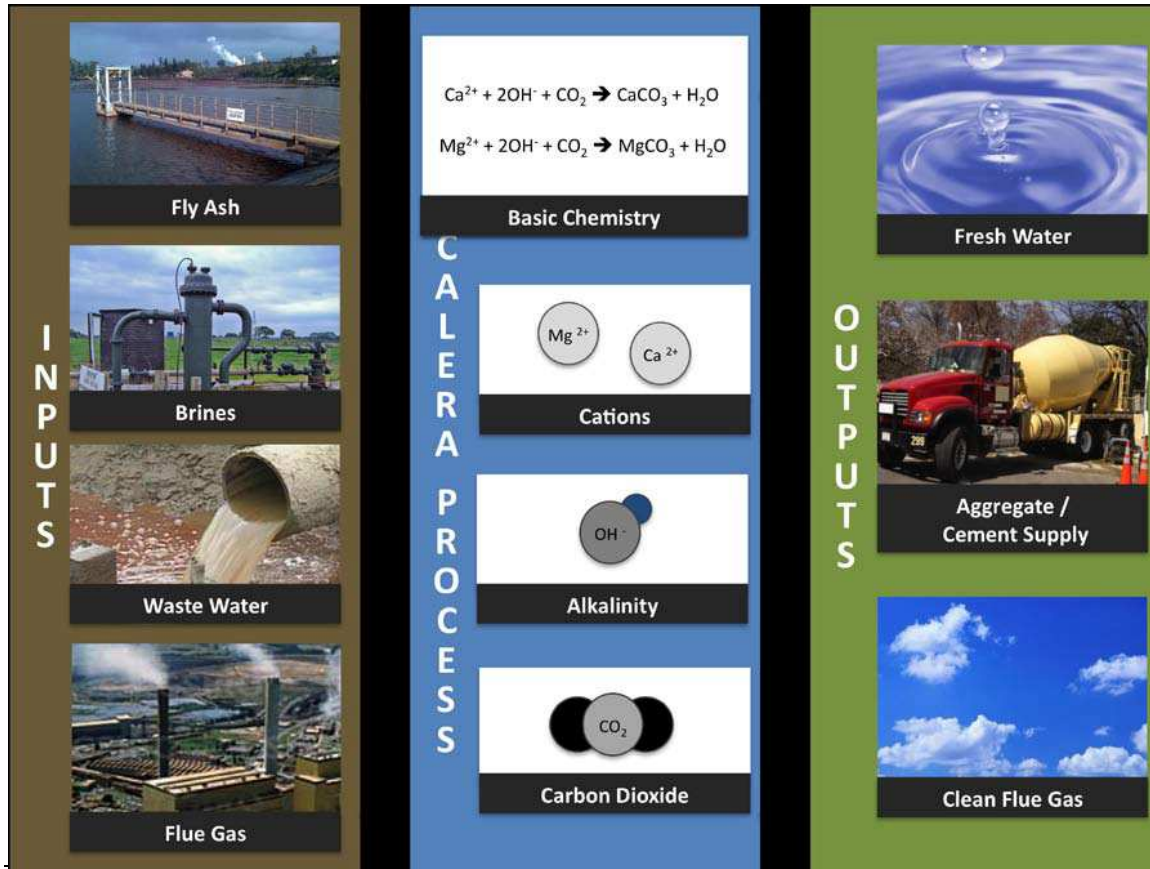
Carbonate Mineralization by Aqueous Precipitation (CMAP) process, which converts CO<sub>2</sub> to carbonate and then binds it to minerals (California Air Resources Board n.d.).

The Calera process is particularly impressive because it addresses a number of climate change threats. The firm's process stores and sequesters carbon, sulfur, mercury, and other toxic gases post-combustion, thus allowing power plants to comply with clean air regulations without incurring high infrastructure costs. Calera estimates it would cost an average coal plant \$1,090/KW to retrofit the infrastructure with CCS Amine and \$1,807/KW if the retrofit includes sulfur dioxide (flue-gas desulfurization), nitrogen oxide (selective catalytic reduction), and mercury (activated carbon injection) (California Air Resources Board n.d.). Calera will cost \$500/KW, thus providing an opportunity for savings to be utilized for efficiency improvements in other parts of the plant (California Air Resources Board n.d.).

Over the last few years there has been much controversy over whether fly ash should be constituted as a hazardous material. Calera is able to capture fly ash and then use it to capture CO<sub>2</sub> in a later process. Likewise, the CMAP process removes minerals from wastewater and leaves behind marketable materials and fresh water. As a result, Calera has discovered a way to create a closed-loop process while, decreasing dependence on foreign nations for construction materials.

Financial stressors are multiplying due to a number of factors including increasing air and water quality standards, saltwater intrusion from excessive groundwater pumping, and surface water contamination from manmade pollutants (Leurig 2010). Increased production in the energy sector is followed by increases in water withdrawals while, increasing use of alternative water sources often results in increasing energy demands for treatment. Therefore, resource planning decisions should not be made in silos or prior to cross regional case study analysis.





**Figure 19:** Inputs and outputs of Calera process (California Air Resources Board n.d.)

### E. Alternative Energy Supplies

Lack of funding and water-intensive energy generation feeds the roadblocks discussed in this study. Many times these issues are engrained in an established setting which is not easy to change such as, existing generation capacity or a regulatory structure. In such instances, it is worth seeking alternative routes or innovative solutions.

Water utilities do not have a lot of funds but what they do have is real estate and real estate is worth a great deal. A number of creative financing tools have been introduced to allow land and facility owners not only make money off unused space, but secure additional and renewable energy sources. The idea behind many of these financing options is that the risk of a project should be apportioned to the stakeholder best able to absorb the risk (Bloom, et al. 2010). There are a number of tax benefits that renewable energy is privy to including the production tax credit, investment tax credit, and accelerated



depreciation. The production tax credit (\$22/MWh-First 10 years in operation) reduces federal taxes for owners of renewable energy based on kWhs produced for the grid while, the investment tax credit is based on capital expenditures (30% of expenditure) (World Resources Institute 2010). Modified Accelerated Cost Recovery System (MACRS) allows one to recover investment capital through depreciation deductions, which depending on date of installment may be a 50% depreciation base applied in the first year (Database of State Incentives for Renewables & Efficiency 2010).

There are a number of financing structures available to allow a real estate owner to benefit from these tax incentives including a partnership flip, partnership flip with pay-as-you-go, sale-leaseback, sale-leaseback with pass-through, inverted lease, and a prepaid power purchase agreement. These structures are methods for developers to access financing from large institutions and split the benefit. Depending on which option is chosen, the investor or developer is able to take advantage of the tax credits while the second party is able to acquire the project after a specified period. For example, in a partnership flip, the developer would receive financial capital assistance from an equity firm which would take advantage of the tax credits till a predefined point. At the predefined point, the developer has the option of regaining control of the project. Through most of these structures it is possible to split the tax benefits. These options may provide a utility with the means to engage financing institutions and developers in a deal which would benefit all parties. Real estate is expensive, therefore entities are willing to split the benefits or provide payment for the use of space to house renewable projects.

1. **Case Study- Creative Financing**
  - a) ***Raleigh Public Utility***

Raleigh is the second-largest city in North Carolina and has a population of approximately 404,000 (U.S. Census Bureau 2011). Raleigh Public Utility provides water and sewer services through 165,000 connections (Waldroup 2011). About 18 months ago Progress Energy approached the utility in regards to a public-private partnership that would provide the city with the option to buy solar panels without having to invest the up-front capital (Carmen 2011). Since the initial meeting additional projects on city property have been initiated.

The project emerged from Progress Energy's SunSense program, which provides a variety of solar incentives to consumers (Progress Energy n.d.). According to Julian Posner, Assistant City Manager of Raleigh, Raleigh Public Utility learned of the opportunity when Progress Energy Carolinas requested proposals for solar generation through third-party development. Mr. Posner explained that without a

third-party, the city would not be able to afford the project considering the price of power. With the assistance of Mike Nicklas of Innovative Design, the city began to research possible locations and concluded with the Neuse River wastewater treatment plant (City of Raleigh n.d.). Progress Energy and the City of Raleigh invited developers to present their solar design and bid for the project. At the end of the assessment Progress Energy and the City of Raleigh agreed on Southern Energy and NxGen Power. This project was the first utility-scale solar project located on government property in North Carolina. In 2010, a similar agreement was made with the developer Carolina Solar Energy for a solar project on the E.M Johnson water treatment plant. The E.M Johnson water treatment plant project will be the first in the northeast to use First Solar's thin-film PV technology (City of Raleigh n.d.).

These projects have a sale-leaseback structure through which utilities offering property leases may invest in without putting any capital down, while developers are able to install solar panels without making heavy investments in real estate. Additionally, developers are guaranteed a competitive rate of 18 cents per kWh from Progress Energy and tax benefits from the federal government (Solar Server 2009). In return, Progress Energy is able to use the project to fulfill its renewable portfolio standard, which is instituted by states to increase renewable generation by requiring retail electric providers to include a specified percent of its portfolio with renewables (Environmental Protection Agency 2009). Through this structure, the city is offered the option of buying the project after the tax incentives have expired, which they expect to take five years. The contract did not set a specified price for the asset, but the Assistant City Manager noted that the estimate is at 20 to 30% of the original cost. After twenty years when the power purchase agreement is completed, the city is able to use the panels for their facilities (Prosser 2011). A good quality panel should last approximately 20 to 25 years; however, after this time it is relatively cheap to repair the deteriorated portions and have it function as new (Miss Solar n.d.).

There are a number of benefits for the water treatment facility as once the solar panels are in the city's property, the city will be able to use them as a supplement to standby generation. Due to intermittency concerns, it would not be wise to completely replace the standby generation with solar; however, it can supplement the generation; thus extending the life of the standby units (Prosser 2011). As a result, this project gives the city the option to purchase a project that will bring extra revenue and possibly supply additional generation in the future.

## VII. Conclusion- The Ideal Framework

Freshwater resources are strained by climate, increasing demand, and water intensive operations. Consequently, sectors highly dependent on the resource may be facing financial and operational burdens during times of low supply. Two sectors which are particularly reliant on water resources are power producers and water suppliers. These sectors face risks not just from their own water requirements but from the requirements of the other sector as well. These risks are the result of the interdependent nature of power and water. In order to manage operational risk and ease water depletion rates, water and power utilities must work together to identify potential solutions. This study provides five recommendations to assist with identified roadblocks to effective water management.

In an ideal framework there would be accurate pricing models, alternative sources of water and energy, and collaborative energy and water conservation programs. There are a number of creative solutions to move the power and water sector to such a framework. However, in order for this framework to be realized, it is first necessary that each sector understands how the other operates.

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