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Water-Energy Sector Collaboration in the United States: Benefits, Barriers, and Climate-Change Implications

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Submitted to the faculty of Clark University, Worcester, Massachusetts, in partial fulfillment of the requirements for the degrees of Master of Science in the Department of International Development, Community, and Environment, and Master of Business Administration in the Graduate School of Management.

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ABSTRACT

**Water-Energy Sector Collaboration in the United States:
Benefits, Barriers, and Climate-Change Implications**

Cassandra Osterhoudt

The purpose of this report is to examine the impact of the water-energy nexus in the United States, and identify opportunities for increased collaboration between water and energy utilities. Through reviewing the regulatory history of both sectors, I explore how regulations on utilities align with the Porter Hypothesis, and the impacts the water-energy nexus will have moving forward, including under climate-change scenarios. The extent of collaboration between sectors has been relatively limited to states with progressive energy and water efficiency policies. This report identifies existing barriers and benefits to collaboration, and utilizes two case studies; California and Massachusetts. Results are used to explore how lessons can be applied to other parts of the United States.

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1.0 Background

1.1 Energy-Water Nexus

Traditionally, the United States water and energy sectors have been studied independently, regulated by separate governing bodies, and provided to customers by separate utilities with differing business models. Widespread research on climate change, and recent developments in the United States have focused attention on the connection between water and energy infrastructure. The interactions that exists between water and energy services are known as the water-energy nexus (Cooley & Donnelly, 2013). In the United States, the energy sector is the single largest user of water in the economy, and conversely energy is a critical component to treating, pumping, and transporting water throughout the United States. Based on this relationship it is clear that saving water means saving energy, and vice versa. Saving water from distribution to end-use can save energy because it reduces the energy needed for water withdrawal and transportation. Saving end-use electricity can save water because it reduces the demand for electricity generation, and the water required in the electricity generation process (U.S. Department of Energy, 2014).

Recent events such as the severe drought that affected more than a third of the United States in 2012, severely limited water resources and constrained the operation of several power plants. Hurricane Sandy demonstrated that vital water infrastructure can be impacted when power is lost. Increasing domestic unconventional oil and gas production by hydraulic fracturing and horizontal drilling – which are water intense - has seen a corresponding large increase in water usage. Increasing research on the impacts of climate change has catalyzed a sense of urgency to address the impacts of the water-energy nexus. Climate change has started to impact precipitation patterns across the U.S., particularly in the Southwest, which is imposing complications to water and energy demands in those states. Additionally, continuing population growth and migration to urban areas has led to complications in the management of already aging water and energy systems (U.S. Department of Energy, 2014).

The flows of water and energy in the United States are intrinsically interconnected due to the networks and systems in place to provide reliable water and energy resources throughout the country. The Sankey Diagram developed by the Department of Energy displays the magnitude of energy and water flows in the United States on a national scale (Figure 1). Thermoelectric power generation withdraws large quantities of water for cooling purposes. Additionally, the agriculture industry competes directly with the energy sector for water resources, and water treatment and distribution for drinking water supply utilize a significant amount of energy (U.S. Department of Energy, 2014).

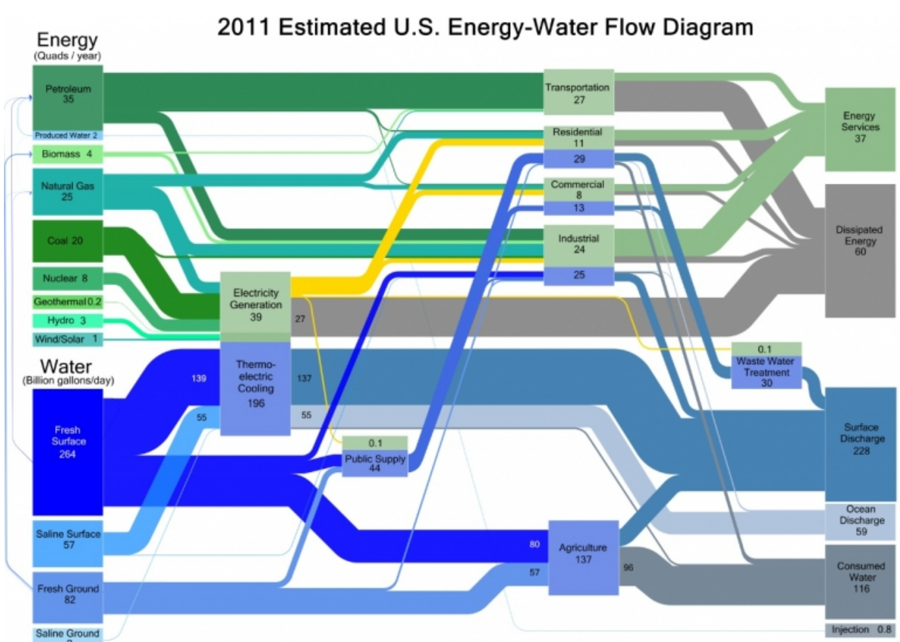

Figure 1| Water-Energy Flow Diagram. Department of Energy, 2014

The decision-making landscape for mitigating the impacts of the water-energy nexus is defined by political, regulatory, economic, environmental, and social factors (Reimer, 2012). The landscape is fragmented across states. Water is inherently a multi-jurisdictional management issue regulated by state and local bodies. State energy policies also vary in regards to energy generation regulations, energy efficiency standards, carbon emission reduction goals, and renewable energy portfolio standards. The importance of the water-energy nexus highlights the opportunity for an integrated approach between sectors for managing the interconnected water and energy challenges (U.S. Department of Energy, 2014).

The introduction of energy efficient technologies in the water and energy sectors offers potential to drastically reduce water and energy demands. Water and electric utility business models have been pushed by federal and state regulations to provide customers with a more service-oriented product where customers are directly connected with their water and energy use, and methods of reducing consumption (U.S. Department of Energy, 2014). While this push is occurring alongside carbon reduction policies, energy and water issues are rarely integrated together into policy (Ambec et al., 2011). This purpose of this paper is to assess the barriers and opportunities for integrated water-energy resource planning across water and energy utilities. First the paper reviews the federal and state regulatory framework impacting energy and water utilities. Then it applies the Porter Hypothesis theoretical framework to highlight the impact regulations have had on progression within the energy and water utility industries. Then this paper will provide context on the types of programs available for integration between water and energy sections, and review benefits and barriers to integration of these programs. Two case studies for California and Massachusetts are presented to provide context for the feasibility of integration between sectors. Drawing from the benefits and barriers, and the two case studies presented, several recommendations are made for future integration and reduction in demand for water and energy resources, including under climate-change scenarios.

1.2 Project Context

This paper is carried out as part of the Dual Degree program which combines a Masters in Business Administration and Masters in Environmental Science and Policy at Clark University. The water-energy nexus is a cross-sector issue that integrates both business management practices and science. This paper is meant to fulfill the requirement of the program Capstone, through combining elements of business and environmental science into one, interdisciplinary report.

1.3 Theoretical Framework

In 1991, Harvard Business School professor Michael Porter asserted that "strict environmental regulations do not inevitably hinder competitive advantage against rivals, indeed, they often enhance it." (Porter & van der Linde, 1995) This was known in the field as the Porter Hypothesis (PH). This idea stood out against the traditional view that environmental regulations forced firms to dedicate resources to externalities, and therefore reduce profits. Based on case studies analyzed throughout Porter and his coauthor Claas van der Linde's work, the authors suggest that pollution created by a company is a waste of resources, and that efforts to reduce pollution can lead to innovation and improvement in the efficiency of resources used. Specifically, the authors cite that good environmental regulations (meaning flexible regulations that work with market pressures) can catalyze innovation, and therefore give companies a competitive edge in the future. Porter and van der Linde (1995) assert five reasons that environmental regulations can improve business performance: (1)

environmental regulations indicate resource inefficiencies and potential for technological improvements in that industry; (2) regulation focused on information gathering can increase corporate awareness; (3) regulations reduce uncertainty that investments to address environmental concerns will be valuable; (4) regulation creates pressure to catalyze innovation and progress; (5) regulation levels the playing field for industries in transition (Porter & van der Linde, 1995)

Since the 1970s, the PH aligns well with how federal and state regulations have catalyzed innovation in regard to energy efficient products, and transformed the energy and water sectors to reduce inefficiencies, and become a more service-oriented industry. Issues with water and energy constraints throughout the 1970s displayed externalities within each sector. In response, state and federal policies called for the restructuring of each industry in order to incentivize reduced consumption of each resource. Through these strict regulations a service based model for each industry was fostered. This catalyzed the presence of demand-side management programs to reduce resource consumption, and energy and water efficient product innovations that are commonplace within each sector today.

1.4 Research Questions

1. What is the current water and energy utility regulatory framework? How has collaboration been driven by federal and state regulations?
2. What are the benefits of and barriers to greater collaboration between water and energy utilities?
3. What are the benefits of and barriers to greater collaboration in California and Massachusetts?

4. Would greater collaboration be a way for California, Massachusetts, and other states to become more resilient to climate change?

2.0 Methodology

2.1 Literature Review

Research for this paper was completed in two stages: a literature review and an analysis of two case studies. The literature review consisted of consulting a body of work on the water-energy nexus, the history of regulation and emergence of demand-side management for electric and water utilities, types of demand-side management programs, and barriers and benefits to coordinated programs between water and energy utilities. This was done by utilizing the publications of several prominent non-profit organizations that are dedicated to increasing the prominence of water and energy efficiency programs throughout the United States. Specifically, the American Council for an Energy-Efficient Economy, the Alliance for Water Efficiency, and the Pacific Institute were used to develop the literature review of this report. The National Climate Assessment 2014 was used to explore the nexus in the context of climate change scenarios for California and Massachusetts.

2.2 Case Study

The two case studies were completed through secondary research on state-level success with water efficiency, energy efficiency and coordinated programs between each sector. California and Massachusetts were chosen for this component of the analysis because they are each leaders in energy efficiency initiatives, and provide a broad perspective on how states with varying water resource environments are responding to the water-energy nexus.

3.0 Findings and Discussion

3.1 Research Question 1: What is the current water and energy utility regulatory framework? How has collaboration been driven by federal and state regulations?

3.1.1 Electric Utility Industry

In the United States, electricity service is considered a natural monopoly. It was industry knowledge that one company could efficiently capture significant economies of scale by providing electricity generation, transmission and distribution technologies to an entire geographic region. The U.S. electric industry includes over 3000 public, private, and cooperative utilities. Electric utilities are split into three categories; investor-owned utilities, publicly-owned utilities, and cooperative utilities. Investor-owned utilities (IOUs) are private companies that are regulated by the state (Dyballa, 2013). They are financed by a combination of shareholder equity and bondholder debt. Approximately 75% of the U.S. population is served by IOUs (Donnelly, Christian-Smith , & Cooley, 2013). Publicly-owned utilities (POUs) are government or municipally-owned utilities that are generally exempt from regulation by state regulatory commissions. Types of POUs include city-owned or municipal utilities, public utility districts and cooperatives. City-owned or municipal utilities are governed by the local city council or a board elected by voters within the service territory. Cooperatives are most common in rural areas, and are governed by a board elected by the customers of the utility. There are 210 investor-owned electric utilities, 2,009 publicly-owned electric utilities, and 883 consumer-owned rural electric cooperatives. (The Regulatory Assistance Project (RAP), 2011).

3.1.2 Electric Utility Demand-Side Management

State regulation of IOU and federal utilities is an integral part of the history of Demand-Side Management (DSM) programs. Historically, electric utilities have been considered a natural monopoly, providing the electricity generation, transmission and distribution technologies for a specific geographic region. State regulatory authorities monitor the establishment of rates in an open administrative forum known as a rate case. Rates cases are meant to give the utility the opportunity to earn a fair profit while also protecting customers from unfair prices. Up until the 1970s, increasing economies of scale for investor-owned electric utilities meant a coupling between increased electricity use and lower prices for all users. Utilities actively promoted new ways to use electricity in order to increase profits, which in turn created a higher demand for fossil fuels (The Regulatory Assistance Project (RAP), 2011).

In the 1970s, however, the dramatic rise in world oil prices lead to significant price increases by utilities that relied on oil and gas. Public concerns for high electricity bills led to increased scrutiny of utility regulation. In addition to this, public awareness of the environmental impacts of electricity generation heightened. Increasing environmental awareness and the energy crisis of the 1970s brought to light the need for energy conservation. In 1978 the Public Utilities Regulatory Policies Act (PURPA) dramatically changed the business dynamics of the utility industry. The act required utilities to purchase power from non-utility generators at prices equivalent to the cost of power the utility would have otherwise generated. This act responded to the conflict of interest between utilities being natural monopolies that have reached economies of scale, which did not allow new energy generators to enter the market. This act essentially forced utilities to purchase power, and only be responsible for transmission to consumers. Additionally, the National Energy Conservation Policy Act (NECPA) of 1978 required that utilities offer on-site energy audits to residential customers. This law was an acknowledgement that saving energy could be cheaper than producing it, and is a more environmentally conscious business model (The Regulatory Assistance Project (RAP), 2011).

DSM programs began in response to both PURPA and NECPA. Under PURPA electricity prices are fixed between rate proceedings, meaning that if the marginal cost of electricity generation exceeds the fixed price between rate proceedings, the utility loses money. In the late 1970s and early 1980s many utilities began to experiment with DSM programs in order to both reduce operating and capital costs, and to reduce peak energy demand. Increasing regulation on energy utilities throughout the 1970s and 1980s introduced the concept of least-cost planning. Least-cost planning is based on the idea that managing customer's energy demands can meet customer energy services at a lower cost than acquiring new generation facilities. Through least-cost planning, energy utilities gave equal consideration to both supply and demand options. The concept of least-cost planning catalyzed increased research and investment in the development of demand-side technologies, and in-depth analysis of saving opportunities from DSM instead of building new power plants.   By the mid 1980s a growing number of states began to recognize the value in increased utility regulation to mandate DSM planning, and adopted least-cost planning regulations for the utility industry (The Regulatory Assistance Project (RAP), 2011). A timeline of electric utility regulation is provided in Figure 2.

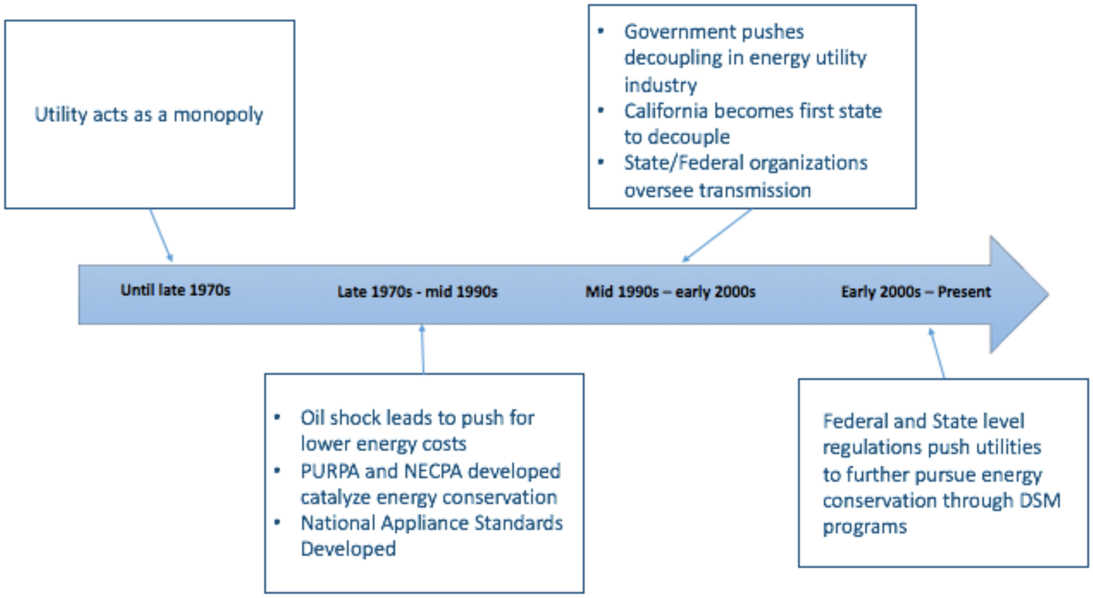

Figure 2 | Energy Utility Regulatory History.

As least-cost planning and DSM programs became more prevalent in the industry, it became apparent that DSM programs should be incorporated into the rate setting process in order to decouple the relationship between electricity consumed and utility profits. Two regulatory strategies were put in place throughout the 1990s in order to create a business case for DSM programs, and to incentivize utilities to invest in infrastructure that reduces electricity demand. The first regulatory strategy provided compensation to utilities for foregone sales that are lost due to cost-effective DSM programs, and the second decoupled utility revenue from sales. Decoupling was established in the mid-1990s by creating a revenue target that is separate from sales, and monitored on a separate balance sheet. At every rate case with the state regulator for energy utilities, rates are adjusted based on the utilities ability to meet the revenue targets. Since the 1990s, 25 states have adopted decoupling for energy utilities (Figure 3) (The Regulatory Assistance Project (RAP), 2011).

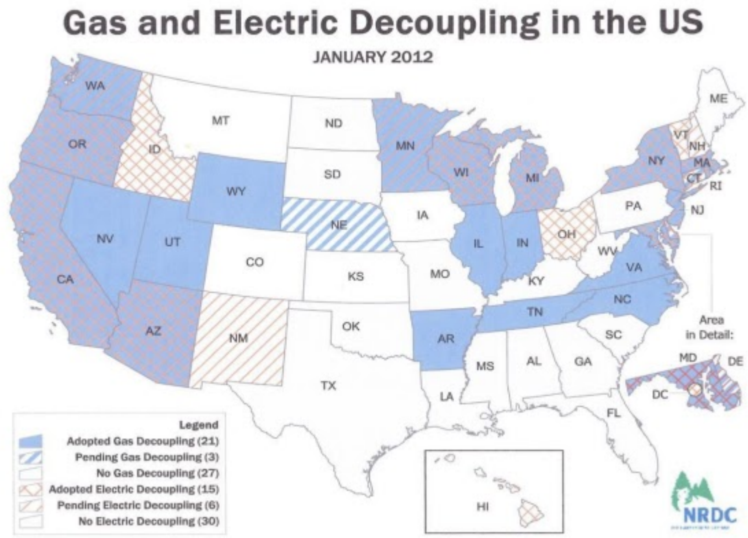

Figure 3 | Energy Industry Decoupling. Natural Resource Defense Council, 2012

3.1.3 Water Utility Industry

The US water sector is primarily composed of public water supply and wastewater collection and treatment facilities. Public-water systems serve approximately 90% of the population, and private wells and other sources supply the remainder of the population. Unlike the electricity industry, the water utility industry is highly fragmented. Variances in local fiscal environment, hydrological conditions, water system age, water system size, density of the public water market, and demand characteristics provide significant difficulties in developing one centralized regulatory framework for the water sector (Reimer, 2012).

There are more than 50,000 water utilities in the United States (Dyballa, 2013). Some serve major cities and have millions of customers, while others serve small communities. 84% of water utilities serve fewer than 3,300 people each. Publicly owned systems account for 46% of total water systems, IOUs account for 15%, homeowner's associations account for 12%, and the remainder is made up of non-community systems that service institutions, schools, or hospitals (Reimer, 2012). The high fragmentation in the water sector has lead to highly decentralized water policy in comparison to the electricity industry. State commissions regulate a small proportion of water utilities to monitor water quality, rates, and investment projects, while smaller water systems are left with relatively fewer resources to devote to these functions. The Environmental Protection Agency is involved in setting quality and environmental standards for utilities (Under the 1972 Clean Water Act & 1974 Safe Drinking Water Act), and providing financial support to the Clean Water State Revolving Funds, and Drinking Water State Revolving Funds (Mann, 1993). Most public and privately owned water systems use variable rate structures. Under variable rate structure plans, water prices either increase (increasing block) or decrease (decreasing block) as consumption increases. This rate structure indicates the lack of decoupling within the water sector. Water utilities rely on water demand for revenues, and therefore have a lack of fiscal pressure to drastically integrate water efficiency efforts (Mann, 1993). A comparison of the electric and water utility industries is provided in Table 1.

Characteristic	Water	Electricity
Number	52,000	Over 3,000
Size and service	400 make up nearly 50% of sales	145 make up 75% of sales
Dominant ownership	Public	Private
State regulation	Drinking water quality	Rates and profits
Rate setting	Local or regional boards	State PUC approved
Revenues	$42 billion	$368 billion
Approach to efficiency	Best practices (mostly voluntary)	Resource standards (mostly mandatory)

Table 1| Comparison of Water and Energy Sectors. *Donnelly, Christian-Smith , & Cooley, 2013*

3.1.4 Water Utility Demand-Side Management

Prior to 1980, little attention was given to managing water demand through DSM programs in the United States. As the United States was experiencing economic growth and population expansion throughout the the twentieth century, however, US cities and towns began to see significant increases in the amount of water withdrawn for consumption. From 1950 to 2000 water usage increased by over 200 percent, which significantly outpaced population growth (population increased 90 percent over the same timeframe), and was indicative of the high standard of living throughout the second portion of the twentieth century (Mann, 1993). The growing consciousness around public water consumption led to supply constraint concerns throughout arid regions of the United States. These concerns catalyzed policies at the federal, state, and local levels to increase efficiency and conservation practices. Simultaneously, the dramatic oil price increases throughout the 1970s that catalyzed energy efficiency in the electricity sector, had echoing positive impacts on efficiency in the water sector. Resource constrained western states pushed water efficiency efforts surrounded 3 main areas: (1) water loss management policies to repair water transport infrastructure; (2) water reuse and recycling programs to improve efficiency; (3) market mechanisms to incentivize conservation and efficiency. Water efficiency policies mainly came in the form of conservation standards that water utilities were required to meet, and federal standards for energy and water efficient appliances. A timeline of water utility regulation is provided in Figure 4.

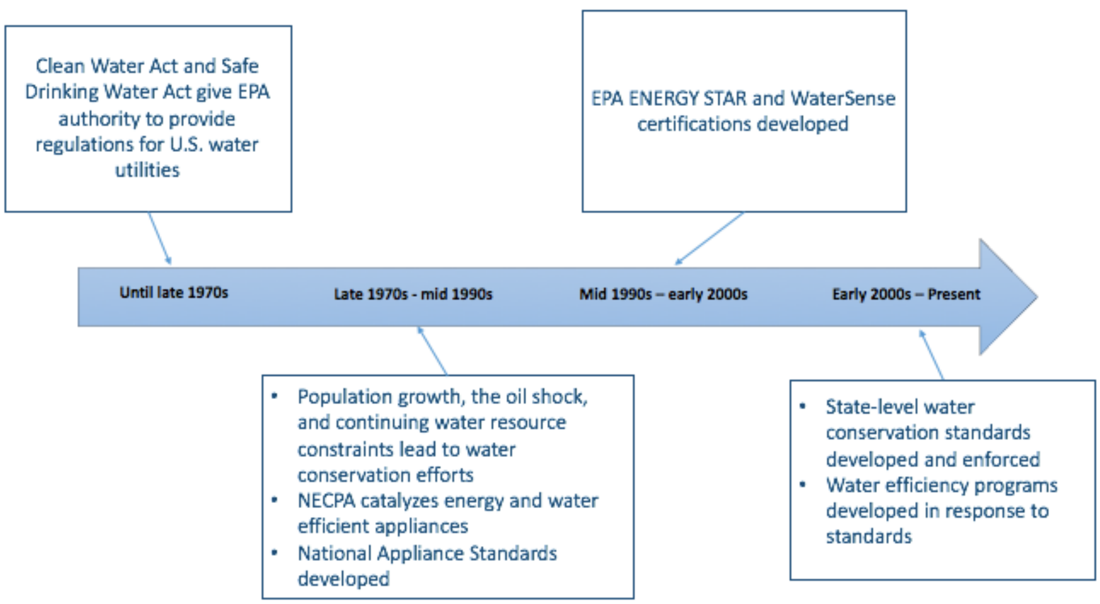

Figure 4 | Water Utility Regulatory History

3.1.5 Energy & Water Efficient Appliance Standards

The first efficient appliance standards were established at the state level. California established the first standard in 1974, and was followed by New York, Florida, and

Massachusetts. Federal energy efficient standards were proposed in response to NECPA in 1978, which gave the DOE the authority to set efficiency standards for thirteen household appliances. Approximately ten years later, however, the National Appliance Energy Conservation Act (NAECA) of 1987, mandated that efficiency standards are regulated on a national level. The act helped to ensure that manufacturers were building products that are at the maximum energy and water efficiency levels that are technically feasible and economically justified. Since the inception of this act, standards have helped to lower the energy intensity of new appliances, and innovation and competition has continued to drive down the price of efficient appliances.

The ENERGY STAR program was created in 1992 to identify and promote energy efficiency products in the market in order to reduce greenhouse gas emissions. ENERGY STAR provides a voluntary labeling program that is run by the EPA and DOE. ENERGY STAR labels were initially only present on office equipment, but have since the program's inception expanded to major appliances, office equipment, lighting, and home electronics (United States Environmental Protection Agency, n.d.). In 2006, the EPA launched a similar program for water efficient products. *WaterSense* is designed to encourage water efficiency through labeling of consumer products that are 20% more water efficient than average products in that category (Environmental Protection Agency, 2017).

3.1.6 State Policy Impacts

Most water and energy utilities determine the extent of efficiency programs from state regulations. Although regulations differ significantly from state to state, most state water conservation standards focus on promoting or requiring water efficiency planning and best management practices (BMPs) for water efficiency. Additionally, more than half of the states require some form of water efficiency planning, 19 require a plan for implementation, and 15 require conservation activities as part of the water permitting process. State energy regulations have begun to adopt statewide resource standards and energy saving performance targets that energy utilities must work towards. 24 states currently have energy performance standards that catalyze energy efficiency programs (Dyballa, 2013). Several states have legislated for energy utilities to acquire all cost-effective energy efficiency resources as a first provider before acquiring new energy sources. In addition to water BMPs and energy efficiency programs, legislation on climate change and greenhouse gas emission targets can catalyze efficiency planning. Greenhouse gas emission targets were developed on a state-level starting in the early 2000s, and have since been implemented in 18 states. Figure 5 displays which states have policy in place for energy, water, and greenhouse gas emission targets.

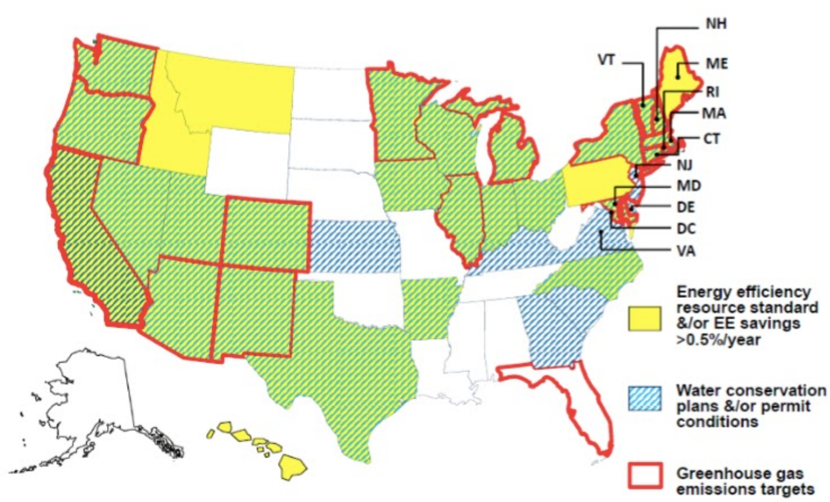

Figure 5 | State-level Energy, Water, and Greenhouse Gas Regulations. Dyballa, 2013

3.1.7 Analyzing utility regulation through the Porter Hypothesis

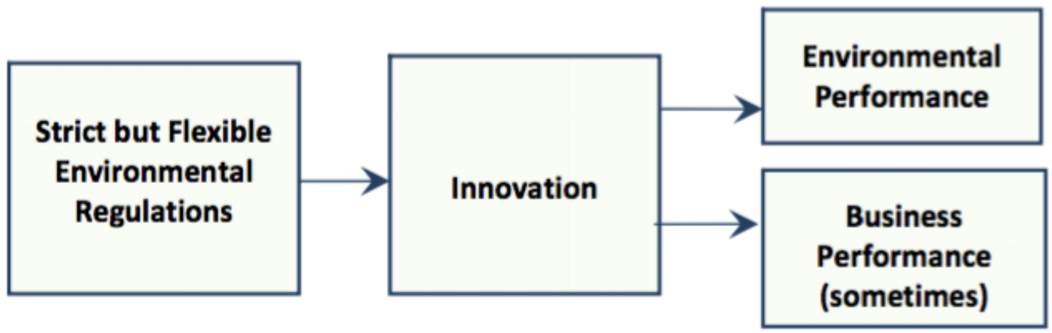

Figure 6 | Porter Hypothesis Diagram. Ambec et al., 2011

The regulatory history surrounding water and energy utilities, and the innovations that resulted from these regulations largely support the tenets of the Porter Hypothesis. The Porter Hypothesis states that environmental regulations catalyze innovation, which in turn leads to environmental and business performance (Figure 6). Water and energy resource constraints catalyzed the presence of regulations in the utility industry. Regulations imposed on the industry range from decoupling in the electric utility industry, to federal and state efficiency appliance standards, state-level water conservation standards, and GHG emissions standards, that have catalyzed the presence of efficient appliances, and Smart technologies. Implementation of these innovations has led to significant reductions in water withdrawals and peak load demand, and have changed the dynamics of the utility industry. DSM programs are now considered a reliable method of avoiding resource constraints in both sectors, and are used to meet state-level environmental regulation standards. Moving forward, the impacts of the water-energy nexus leave room for further regulations in regards to collaboration between water and energy sectors, and R&D efforts to reduce the connection that exists between water and energy resources. A review of how the regulatory history of energy and water utilities aligns with the five tenets of the Porter Hypothesis are outlined below.

5 Tenets of Porter Hypothesis (Ambec et al, 2011):

(1) *Environmental regulations indicate resource inefficiencies and potential for technological improvements in that industry*

   a. Dramatic rises in oil prices, and high water consumption rates throughout the 1970s indicated that resource inefficiencies exist in the utility sector. PURPA and NECPA were implemented in the late 1970s, and Federal Appliance Regulations were implemented in the 1980s to reduce the impact of these inefficiencies. PURPA and NECPA catalyzed the restructuring of the energy utility industry in order to eliminate the link between energy sales and revenue, and appliance standards were developed in order to improve the impact of demand side management programs.

(2) *Regulation focused on information gathering can increase corporate awareness*

   a. Appliance Regulations were developed in order to increase the impact of demand-side management programs and optimize consumer efficiency. The R&D involved with developing energy and water efficient products increased federal, corporate, and public awareness on the resource intensity for common in-home appliances and daily tasks, and created business opportunities for developing and distributing efficient appliances to consumers.

(3) *Regulations reduce uncertainty that investments to address environmental concerns will be valuable*

a. State-level water conservation and GHG emission policies have mandated that all utilities implement demand-side management programs in order to achieve reduction goals. These policies usually require reduction goals to be met by a specific deadline, which incentives utilities to make the necessary investments in order to avoid fines, and remain relevant and innovative within the utility industry. Proven savings for efficient appliances further reduces uncertainty for investment in demand-side management programs. Industry data clearly indicates the magnitude of savings from efficient appliances, and therefore allows utilities to quantify demand-side management program investments based on data available from R&D efforts.

(4) *Regulation creates pressure to catalyze innovation and progress*

a. PURPA and NECPA catalyzed the presence of R&D efforts for more efficient in-home appliances. State and federal appliance regulations, and certification programs for efficient appliances arose as a result of these regulations, and significantly increased the impact of demand-side management programs. These regulations have also resulted in an entire industry based around development of efficient appliances and Smart technologies, and making these technologies widely available to consumers.

(5) *Regulation levels the playing field for industries in transition*

a. From the establishment of PURPA and NECPA in the late 1970s to decoupling of electric utilities in the 1990s represents a period of transition for the electric utility industry. Utilities across the nation were subject to PURPA and NECPA and responded with demand-side management programs. While certain states throughout the country were more progressive in regards to efficiency efforts, these regulations catalyzed R&D efforts across all utilities to develop effective demand-side management programs, and gain a quantifiable understanding of the benefits available through these programs.

3.2 Research Question 2: What are the benefits of and barriers to greater collaboration between water and energy utilities?

3.2.1 Demand-Side Management Programs

Demand-side management (DSM) programs are efforts by electric, gas, and water utilities to modify customer's energy and water consumption patterns. DSM programs are divided into six categories: (1) general information provided to increase customer awareness on their energy use and ways to save energy; (2) technical information, which includes energy audits that provide energy efficiency upgrade recommendations; (3) financial assistance in the form of loans or direct payments to lower energy-efficient technologies; (4) direct or free installations of energy-efficient technologies; (5) load control or load shifting, in which the utility offers financial payments or bill reductions in return for controlling customer use of specific devices; (6) innovative pricing structures such as time-of-day or real-time prices to encourage customer behavior change (California Sustainability Alliance, 2015).

3.2.2 Benefits of and barriers to joint programs

The history of demand-side management programs, and inherent links that exist between water and energy consumption in the United States provides a foundation for increased collaboration between sectors. Energy efficiency is a proven cost-effective way to reduce water use in the power sector, and water efficiency programs can reduce the energy used at water and wastewater facilities. Because efficiency programs reduce energy demand, they also reduce the need to generate electricity, and reduce the amount of water used in the electricity generation process. Additionally, end-use water efficiency programs reduce the energy demand needed to treat and transport water to consumers. The inherent link between water and energy, however, is not the only reason for increasing collaboration for DSM program facilitation. In a recent report developed by ACEEE (2016), benefits to joint program facilitation are outlined.

The first benefit is that *joint programs can help utilities to obtain a greater benefit per customers* (American Council for an Energy-Efficient Economy, 2016). Water efficiency programs often struggle with the cost-effectiveness of implementing the program and limited staff time to do so. Joint programs between water and electric utilities, however, can be executed to save both water and energy, and also share the financial burden between both companies involved in facilitating the program. Through facilitating dual water and energy audits, rebate programs, and education and outreach efforts utilities can reduce the amount of staff investment needed to administer each program. Utilities do not need to dedicate extra resources to engaging with customers separately, and can instead show customers both water and energy efficiency resources. Additionally, *joint programs have the ability to increase cross-sector knowledge of the relationship between water and energy through sophisticated tracking, metering and evaluating* (American Council for an Energy-Efficient Economy, 2016). Sharing data on where energy and water savings have occurred on both the demand and supply side will increase industry knowledge on the exact impacts of the water-energy nexus, and catalyze water-energy footprinting methods for the utility industry.

Water and electric utilities have significant differences in their business structure and regulatory environment, which creates barriers to implementing joint demand-side management programs. Several studies have interviewed electric and water utilities throughout the country to determine what the most prominent barriers are to implementing joint programs. The Pacific Institute published a report in 2013 where they outlined the top ten barriers to coordination between water and energy utilities in California. The barriers were determined by a comprehensive survey of water and electric utility personnel, state regulators, academic institutions, and prominent consulting firms. The top 10 barriers found through this survey are (Table 2): (1) Limited or inconsistent funding available from the water sector for combined programs, (2) Limited Staff Time, (3) Insufficient guidance for allocating costs between project partners, (4) water-related pricing policies, (5) lack of established relationship among potential partners, (6) Insufficient guidance on how to quantify water, energy, and cost savings, (7) Poor quality or insufficient data to quantify water and energy savings, (8) Inability to share customer data/customer privacy concerns, (9) Significant temporal and spatial variability in determining water, energy, and cost savings, and (10) Too much emphasis on getting perfect information before starting programs (Table 2)(Cooley & Donnelly, 2013).

1	Water sector has limited or inconsistent funding available to invest in combined programs.
2	Limited staff time.
3	Insufficient guidance about how to equitably allocate costs and benefits among project partners.
4	Water-related pricing policies (e.g., few mechanisms for cost recovery and concern about revenue stability).
5	Lack of established relationship between potential water and energy partners.
6	Insufficient guidance on how to quantify water, energy, and cost savings.
7	Poor quality or insufficient data to quantify water and energy savings.
8	Inability to share customer data/customer privacy concerns.
9	Significant temporal and spatial variability in determining water, energy, and cost savings.
10	Too much emphasis on getting perfect information before starting programs.

Table 2 | Barriers to Collaboration. Cooley & Donnelly, 2013

3.2.3. Analyzing joint utility programs through the Porter Hypothesis

The tenets of PH also align with the opportunities available through joint water and energy utility programs. Although specific policies that mandate joint programs do not exist, state regulations regarding greenhouse gas emissions, energy efficiency, and water conservation are pushing states to develop more efficient and cost effective methods of mitigating the impacts of the water-energy nexus. Joint DSM programs have occurred as a result of these regulations, and can be classified under PH as an innovation in response to regulation. The results of joint programs in California, and increased collaboration in Massachusetts highlight that combining water and energy utility resources for facilitating DSM programs can reduce costs, lead to increased savings, and foster environmental and business performance.

3.3 Research Question 3: What are the benefits of and barriers to greater collaboration in California and Massachusetts?

3.3.1 California Case

California is credited for being the leading state for utility sector energy and water efficiency programs. California was the first state to initiate decoupling for electric and natural gas utilities, and the first state to develop energy efficiency standards for in-home appliances (American Council for an Energy-Efficient Economy , 2016). The relationship between water and energy in California exemplifies the importance of a collaborative approach to the water-energy nexus. Approximately 19% of electricity use and 30% of non-power plant-related natural gas use in California is associated with water consumption. Additionally, water is required to produce electricity from both hydroelectric and thermoelectric power plants (Klein, 2005). 2011 through 2014 marked the driest years in California history (Figure 7). The severe drought that has been present since late 2011 has forced state officials to declare a state of emergency, and has mandated a statewide 25% reduction in urban water use. The severity of the drought has established stringent water efficiency regulations, and catalyzed the conversation for improving integration between water and energy sectors to achieve further savings in both resources (California Water Association , 2017).

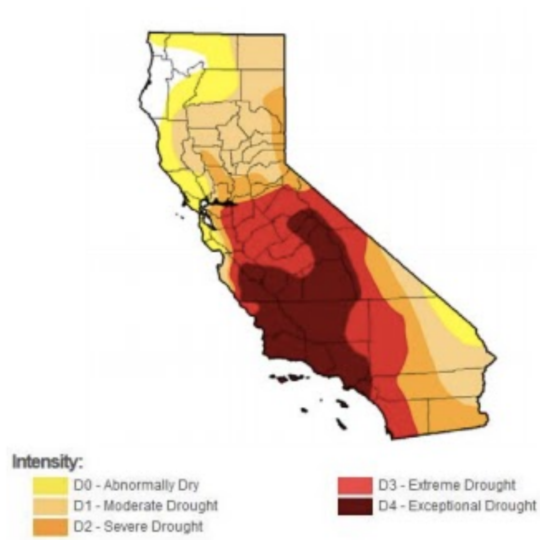

Figure 7 | California Drought Classification. U.S. Drought Monitor, 2016

Water Landscape

Majority of water utilities in California are public entities governed by publicly-elected boards, and state regulations. California has more than 1,000 water suppliers, ranging from utilities serving large metropolitan areas to mobile home parks (Figure 8) (California Water Association , 2017). Water is essential to supporting and sustaining California's environmental, economic and public health needs. The Water Conservation Act of 2009, is one of the state's prominent pieces of legislation to help reduce water consumption and drought conditions. The Act established a goal of achieving a 20% reduction in urban per capita water use by 2020. The law requires that urban water suppliers develop water use targets to meet the requirements of this act in their water management plans. If water suppliers do not meet the water conservation requirements, they will not be eligible for state water grants or loans. In response to the Water Conservation Act, many state agencies have developed plans that provide recommendations for meeting the state's water conservation policies. Specifically, state agencies call for improving efficiency standards for buildings and appliances, providing incentives for water efficiency and increasing enforcement of existing water efficiency regulations (California Sustainability Alliance, 2015).

Figure 8 | California Water Utilities. California Water Association, 2017

Energy Landscape

Majority of energy utilities are privately owned, and the state provides a regulatory framework that clearly defines how these utilities determine customer rates. As of 2012, 65% of total electricity demand was provided by IOUs. California has six electric IOUs with the largest ones being Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric Company (SDG&E) (Figure 9) (Cooley & Donnelly, 2013). The IOUs are governed by a board of directors elected by the company's shareholders, and are regulated by the California Public Utilities Commission (CPUC). Additionally, 24% of the state's total electricity demand is provided by publicly-owned utilities (POUs) (Cooley & Donnelly, 2013). The two largest POUs in the state are the Los Angeles Department of Water and Power (LADWP) and the Sacramento Municipal Utility District (SMUD). The POUs are governed by publicly-elected boards and city councils that are subject to laws and regulations established by state and local governments. Lastly, California also has two Native American utilities, and four electricity cooperatives that are private, independent, nonprofit utilities that are owned by the customers they serve (Cooley & Donnelly, 2013).

Figure 9 | California Electric Utility Service Areas. California Energy Commission, 2015

Supply Adjustment Mechanism (SAM) & Electric Restructuring Act

California was the first state to implement decoupling through the Supply Adjustment Mechanism for gas utilities in 1978 in response to rising world oil prices. By 1982, similar mechanisms were put in place for several electric IOUs in the state. Decoupling was suspended briefly in 1996 due to the federal Electric Restructuring Act, and resumed again in 2001 (Chang & Rosenfeld, 2007).

California Energy Action Plan & The Global Warming Solutions Act

The 2003 Energy Action Plan is the second major policy initiative that catalyzed the presence of energy efficiency programs as a cost-effective and reliable source for reducing energy consumption. The Energy Action Plan establishes that cost-effective energy efficiency and demand response are the state's top priority procurement resources, followed by renewable energy generation, and finally cleaner and more efficient fossil-fuel generation, such as natural gas. After examining energy efficiency improvements in the state, in 2006 The Global Warming Solutions Act was passed. This act established comprehensive programs to reduce greenhouse gas emissions from all sources throughout the state. The act required that the state reduce greenhouse gas emission levels to 2000 levels by 2010, to 1990 levels by 2020, and to a level 80% below 1990 levels by 2050 (Chang & Rosenfeld, 2007) . Through this act, the CPUC mandated that energy utilities invest in energy efficiency whenever it is cheaper than building new power plants, and also mandated that energy utilities monitor the costs and savings associated with energy efficient programs in order to develop rigorous evaluations of savings, and integrate energy efficiency programs into forward planning for energy resources. By 2006, California utilities began launching aggressive programs to achieve energy savings goals. From 2006 - 2008, utilities budgeted $2 billion to deliver energy efficiency programs, and obtained $3 billion in net benefits to California's economy through reduced energy bills and avoided construction of new power plants (American Council for an Energy-Efficient Economy , 2016).

Coordinated Programs

In response to the impacts to water shortages across the state, statewide policies for water conservation, energy conservation, for GHG reduction mandates, several studies have been completed to demonstrate that saving water saves energy and can be highly cost effective. A 2005 study by the California Energy Commission, found that water-efficiency improvements in the state could provide as much savings as some of the existing energy efficiency programs, at half the cost (Klein, 2005). Recent analysis of potential savings has pushed the Pacific Institute to analyze the extent of coordination that exist between sectors in California. The Pacific Institute highlights 4 case studies that exemplify the potential for savings and the overarching benefits for coordination (Cooley & Donnelly, 2013).

(1) *PG&E and Bay Area Water Agencies: High Efficiency Clothes Washer Program*

a. In 2006, Pacific Gas and Electric partnered with all Bay Area water municipalities to develop a single coordinated rebate program for High-efficiency clothes washers (HECW). Since the late 1990s, Bay Area water utilities each offered their customers individually managed rebate programs. In 2001, all water utilities offering this program developed a regional rebate program, and contracted out the administrative work to a third party. Pacific Gas and Electric was concurrently offering a parallel HECW program with different rules and conditions to customers. In 2006, PG&E approached all water utilities currently administering the program to develop a single, HECW rebate program for all residential customers in the Bay Area. The collaboration resulted in 27 Bay Area water utilities, the Bay Area Water Supply and conservation Agency (BAWSCA) and PG&E each dedicating resources to administer this program. Prior to the development of the joint program, customers would have to fill out two separate rebate applications; one for the water utility and the other for PG&E, and then the customer would receive two separate rebate checks. Through streamlining the program customers complete one application online, and each week the contractor sends a list of applicants to PG&E and the water utilities to verify the applicant is eligible for the program, and the customer receives one rebate check. The program runs on a yearly contract, where water utilities and PG&E approve the year's product specifications and total rebate amount, and then each dedicate resources toward third-party program administration. Coordination has significantly expanded the reach of the program, made customer participation easier, and improved cost effectiveness in comparison to the regional water rebate program. Before the joint program was implemented, one utility paid $18 per rebate for processing and administrative costs. Under the joint program, administrative and processing costs are split across utilities to approximately $10 per application (Cooley & Donnelly, 2013).

(2) *SDG&E and SDCWA: WaterSmart Landscape Efficiency Program*

a. San Diego Gas & Electric (SDG&E) and the San Diego County Water Authority (SDCWA) have collaborated on water and energy efficiency programs for over 20 years. Past programs have included distributing low-flow showerheads, performing energy efficiency audits at water agency facilities, and providing joint rebate programs. In 2006, in conjunction to the Global Warming Solutions Act, the CPUS required all IOUs to examine embedded energy savings associated with water efficiency. In response to this, SDG&E and SDCWA developed three new pilot water efficiency programs: water/energy audits, a landscape irrigation management program, and a recycled water program. The landscape irrigation management program utilizes smart irrigation control technology in order to save water at large commercial landscapes. Smart irrigation technology uses climate-based controllers that rely on weather information to adjust the amount of water used for irrigation. For the program, SDG&E selected a water management service company to market the program, assess savings potential savings, enroll customers and install and monitor the systems installed. The program implemented smart-controllers at 13 sites. Throughout the timespan of the pilot program, an average water savings of 35% was achieved (Cooley & Donnelly, 2013). Building off of the learnings from this pilot program, SDG&E and SDCWA developed an updated program that incorporated industry-wide training that enables contractors to implement water budgeting technologies to reduce outdoor irrigation. The purpose of this approach was to increase scalability and enable multiple contractors to administer efficiency programs throughout different territories. In order to participate in the program, contractors were responsible for several tasks: retrieving historical water use records to calculate baseline water use, establishing a water budget, identifying and installing hardware upgrades to improve irrigation efficiency, and tracking and reporting monthly water use to a online reporting system (Cooley & Donnelly, 2013).

(3) *SoCalGas and West Basin*

a. West Basin Municipal Water District provides wholesale drinking and recycled water to cities and private companies. Starting in 2009, West Basin has partnered the South Environmental Services Center (SBESC) to implement Cash for Kitchens (C4K) program. C4K is a water efficiency audit program for over 600 commercial kitchens in the West Basin area. SBESC provides technical and program support for Los Angeles area municipalities in regards to energy efficiency projects, and connects regional customers with water and energy efficiency rebate and incentive programs. SBESC is responsible for organizing and conducting the C4K audits and is the primary point of contact for all participants in the program. C4K audits identify inefficient appliances, record information on installed water appliances, flow rates, and leaks; and create customer reports to summarize recommended water and energy saving techniques. In addition to the audit, training sessions on energy and water efficiency are also offered to kitchen employees. This program was initially funded with grant money from the Metropolitan Water District of Southern California. The grant covered water-saving devices and marketing and outreach materials. Program operations are funded by West Basin, and SBESC is paid for their services on a monthly basis (Cooley & Donnelly, 2013). In 2011, SBESC worked to partner the resources of West Basin with SoCalGas on the audit program. SoCalGas had been operating a natural gas audit program for commercial customers that was working to ensure natural gas fixtures are operating at maximum efficiency. Both companies thought that conducting both audits at the same time could provide mutual benefits and was a more efficient use of resources for both the agencies and customers. As of March 2013, more than 230 C4K audits had been completed, with 70% incorporating both gas and water efficiency efforts. West Basin and SoCalGas have stated that this program has provided several important benefits: it has enabled them to reach a larger number of customers, and drastically reduced the amount of staff time needed to identify facilities and complete audits (Cooley & Donnelly, 2013).

(4) *SoCalGas and LADWP: Master Inter-Utility Agreement*

a. The Los Angeles Department of Water and Power (LADWP) and Southern California Gas Company (SoCalGas) recently started a joint implementation of energy and water efficiency programs in their overlapping service territories. LADWP provides electricity and water service to over 4 million residents in the Los Angeles area, and SoCalGas is an IOU that services nearly 21 million customers throughout 500 communities throughout Central and Southern California. LADWP provides electricity and water services to over 20% of SoCalGas's customers. In response to California's Energy Action Plan and Global Warming Solutions Act, California POUs and IOUs were required to invest in energy efficiency programs prior to obtaining new sources of energy in order to meet the statewide 10% reduction in energy use over 10 years goal. Additionally, IOUs were required to determine the potential energy efficiency savings within their service area. With both SoCalGas and LADWP having their own ambitious efficiency programs in place, the companies decided to establish a formal partnership in order to increase the benefits of efficiency programs. Both companies signed a Master Inter-Utility Agreement (MIUA) which outlined the general terms and conditions for efficiency program implementation. Specifically, the agreement establishes disclosure guidelines for customer information, sets terms and conditions for work/proprietary information, reporting energy and water savings, and methods of measurement and verification of savings. The purpose of signing a MIUA is to enable joint programs between companies without having to completely reinvent the program administration process. By 2013, LADWP and SoCalGas invested $440 million for joint efficiency programs, and had implemented nine joint programs (Table 3), and intended to implement an additional 12 programs by the end of 2013 (Cooley & Donnelly, 2013). Each program administered has a lead utility that is responsible for coordinating with customers, processing applications, and handling the measurement and verification of savings. The partner utility that is not administering the program shares in the costs and assists in the program development and marketing. For most of the joint programs, the lead utility has already begun implementing a version of the program, and only modifies the program to incorporate the interests of the partner utility. The success of coordination between SoCalGas and LADWP has catalyzed an effort from both companies to utilize the MIUA method to foster additional partnerships between other utilities in the region (Cooley & Donnelly, 2013). An overview of the programs implemented through the MIUA is provided in Table 3, and an overview of joint programs in California is provided in Table 4.

Program Name	Program Description	Lead Agency
Small Business Direct Install	Free direct-install program that targets small- to medium-sized business for general lighting, water conservation measures, and natural gas conservation measures	LADWP
LAUSD Direct Install	LADWP engineering and Integrated Support Staff provide the Los Angeles Unified School District (LAUSD) with technical design, project management experience, and installation of lighting, water and natural gas measures	LADWP
Retrocommissioning Express	Offers cash incentives to non-residential customers who undertake a "tune-up" of their existing building system equipment to restore equipment to its original performance level, as designed, if not higher. Incentives are available for 13 measures, including lighting sensors, fan and pump variable frequency drives, and chilled water and condenser water	LADWP
Energy Upgrade California	Offers incentives to homeowners who complete selected energy-saving home improvements on single-family residences or 2-4 unit buildings, such as a townhouses, condominiums, etc.	SoCalGas
California Advanced Homes	Provides an incentive (financial, technical assistance, etc.) to primary decision-makers in residential new construction projects to exceed Title 24 efficiency standards for new construction, including single and multi-family high-rise buildings	SoCalGas
Savings by Design	Offers up-front design assistance, owner incentives, design team incentives, and energy design resources to encourages energy-efficient building design and construction practices for new non-residential construction	SoCalGas
Multi-Family Direct Therm Savings (Energy Smart)	Provides no-cost energy audits, products, and their installation for multi-family buildings. No-cost products include: showerheads, kitchen aerators, bathroom aerators, and pipe wrap for the hot water distribution system	SoCalGas

Table 3 | LADWP and SoCalGas Master Inter-Utility Agreement Programs. Cooley & Donnelly, 2013

Program	Participating Utilities	Location	Regulatory Implications	Highlighted Program Successes
High Efficiency Clothes Washer Program	*PG&E and Bay Area Water Agencies*	CA	Energy Action Plan, Global Warming Solutions Act	Reduced PA costs from $18 per rebate to $10
WaterSmart Landscape Efficiency Program	*SDG&E and SDCWA*	CA	Energy Action Plan, Global Warming Solutions Act	Average water savings of 35% achieved
Cash for Kitchens (C4K)	SoCalGas & West Basin	CA	Energy Action Plan, Global Warming Solutions Act	More than 230 C4K audits completed, 70% combined gas and electric audits
Master Inter-Utility Agreement	SoCalGas & LADWP	CA	Energy Action Plan, Global Warming Solutions Act	Development of first Master Inter-Utility Agreement

Table 4 | California Joint Demand Side Management Programs

3.3.2 Massachusetts Case

Massachusetts is currently the leading state in energy efficiency, and a has developed noteworthy efficiency programs, but has so far developed very few programs that integrate water and energy utilities. Massachusetts is given a #1 ranking in regards to energy efficiency by the American Council for an Energy-Efficient Economy (ACEEE). The state provides a variety of tax incentives, grants, and rebate programs to catalyze the presence of energy and water efficient buildings, energy efficient fleets and the availability of EnergyStar and WaterSense certified technologies (American Council for an Energy-Efficient Economy , 2016) .

Water Landscape

Water Systems in Massachusetts are either investor-owned companies or municipalities owned by cities and towns. Investor-owned companies are subject to state regulation by the DPU, and municipal corporations are owned by cities and towns, and serve as independent public organizations dedicated to providing water and sewer services. The Massachusetts DPU currently only regulates 19 IOU water suppliers, with the rest being either public municipalities or are organizations developed by state government (Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs , 2017). Massachusetts has been a leading state in the field of water resource protection through both water conservation and efficiency. Massachusetts statewide Water Policy developed in 1992 with the Water Conservation Standards, and were updated in 2006. The Water Conservation Standards set statewide goals for water conservation and water use efficiency, and provide guidance on effective conservation measures to meet statewide goals (Commonwealth of Massachusetts Executive Office of Environmental Affairs, 2004). The standards and recommendations are meant to be used in all programs affecting the planning and management of Massachusetts water resources, including the Water Management Act, Interbasin Transfer Act and Massachusetts Environmental Policy Act. There are 10 standards that cover key areas ranging from water planning, water pricing, residential, public sector and agricultural use, and public education and outreach. In regards to water conservation and demand-side management, Standard 5.0 encompasses residential water efficiency and requires residential water use to be at 65 gallons per capita per day (gpcd), and requires water utilities to implement comprehensive residential water conservation programs to reduce residential water use (Commonwealth of Massachusetts Executive Office of Environmental Affairs, 2004).

The MWRA is a public authority, established in 1984 that supplies wholesale water to local water departments in 48 communities in the greater Boston and MetroWest areas (Figure 10). In 2011 the system supplied an average of 195 million gallons per day (MGD) of potable water and treats an average of 350 million gallons of sewage per day. MWRA water comes from the Quabbin Reservoir and the Wachusett Reservoir (Figure 11). In the course of providing water in 2011, the authority consumed approximately 210 GWh of electricity and 493,250 Therms of natural gas. The two reservoirs supply an average of 200 million gallons of water per day to consumers (Massachusetts Water Resources Authority, 2016).

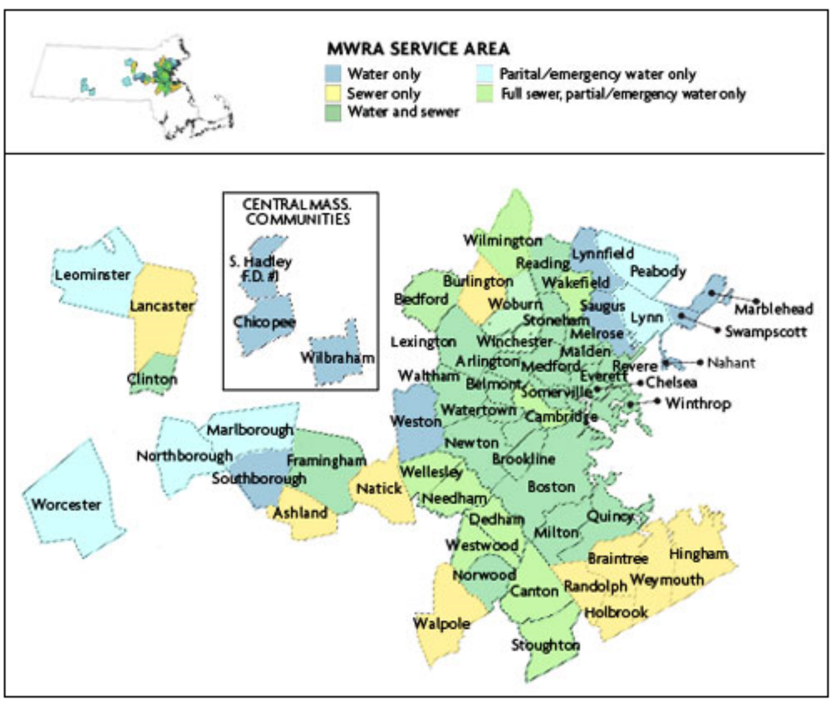

Figure 10 | MWRA Service Area. MWRA, 2016

Figure 11 | Overview of MWRA Water System. MWRA, 2016

Energy Landscape

Massachusetts energy utilities are separated into IOU and municipal utilities. 85% of the Massachusetts population is served by IOUs, and 15% of the population is served by municipal utilities (Figure 12) (Executive Office of Energy and Environmental Affairs , 2011).

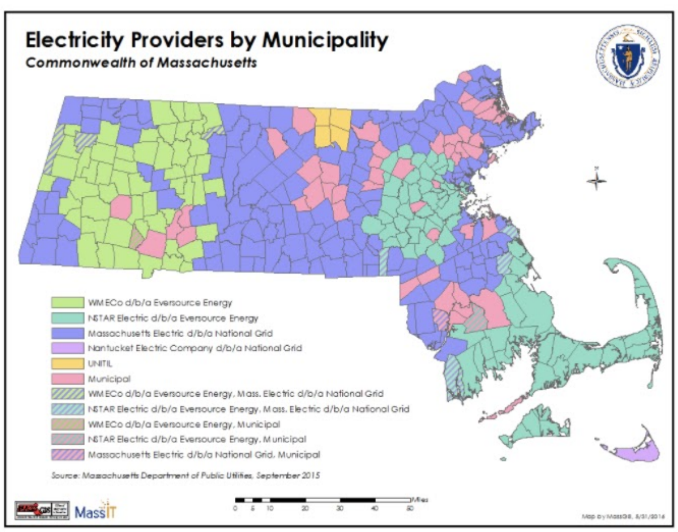

Figure 12 | Massachusetts Electricity Providers. MassGIS, 2015

Electric Restructuring Act & Massachusetts

Massachusetts restructured the utility industry during the 1997 Federal Electric Restructuring Act. This act required that utilities remove themselves from the power generation business, in order to decouple electric and gas utilities revenue from sales. The purpose of this act was to ensure that fair competition prevailed among power generation companies. Results of this act catalyzed a switch from residual oil and coal to natural gas, and significantly reduced the impact of power generation on air quality and carbon emissions. The restructuring act also changed the components of utility bills by charging for delivery services and for supply services. The Electric Restructuring Act serves as a regulatory method to create a market framework to catalyze the presence of cleaner energy sources in Massachusetts (American Council for an Energy-Efficient Economy , 2016).

Green Communities Act

In 2008, the governor of Massachusetts signed the Green Communities Act. The Green Communities Act built off of the framework established through the 1997 Restructuring Act, and provided a more explicit plan for catalyzing energy security and cleaner energy resources for the state. The act required that all electric and gas utilities procure all cost-effective energy efficiency before procuring new supply resource. The Act created the Energy Efficiency Advisory Council (EEAC) that works with utility program administrators to establish three-year statewide energy efficiency plans for gas and electric utilities. The first electric efficiency procurement plan in 2009 provided incremental savings of 1.0%, 2010 provided 1.4%, 2.0% in 2011, and 2.4% in 2012. The 2016-2018 procurement plan calls for savings to increase to 2.95% of annual sales in 2018. Massachusetts 2016-2018 natural gas plan will save 85.8 MWTherms (Hibbard, Tierney, & Darling, 2014).

Coordinated Programs

(1) *MWRA Long Range Water Supply Program*

a. The MWRA has pursued water efficiency initiatives since its establishment in 1984. For a 20-year period before the MWRA was enacted, its predecessor the Metropolitan District Commission (MDC) routinely drew more than the safe yield from the Quabbin and Wachusett Reservoirs. The program focuses on controlling water costs for customers, and environmental sustainability through active management of water and energy resources. The MWRA long range supply program aims to avoid the need for developing new water resources, and constructing new pumping and transportation infrastructure through facilitating water conservation. The water conservation program started in 1987 in response to water use in Massachusetts exceeding the safe yield of 300 MGD (Massachusetts Water Resources Authority, 2016). The MWRA predecessor, the Metropolitan District Commission had through extensive environmental review planned to divert flow from the Connecticut River in order to meet demand. However, the project was facing local and regional opposition, and instead chose to direct the program towards improving efficiency through a large-scale demand management program in order to reduce water consumption to below safe yield for the reservoir. The program was designed to reduce demand from the reservoirs to the consumers tap, and to protect existing water supplies from contamination (Young, Saving Water and Energy Together: Helping Utilities Build Better Programs, 2013).

The original program includes 25 separate DSM programs. Programs ranged from industrial, commercial, and institutional audit and outreach programs, direct installation retrofits for residential customers, outreach and education programs on conservation at area schools, and supporting the adoption of a 1.6 gallon per flush toilet standard in Massachusetts (Young, Saving Water and Energy Together: Helping Utilities Build Better Programs, 2013). Operation WaterSense, was an early residential program that was completed in partnership with member communities, in which a door by door approach was taken for no-cost direct installation of water efficient devices. The program achieved a 59% participation rate and a 95% customer satisfaction rate (Young, Saving Water and Energy Together: Helping Utilities Build Better Programs, 2013). The program provided direct installations from 1988 to 1993, and still exists today in the form of available low-flow device kits to MWRA customers. The program also implemented water system efficiency efforts at MWRA facilities, and leak detection and repair programs in order to improve water system infrastructure. Over the 25 years of the program, MWRA water demand dropped from 340 MGD (over safe yield) to 200 MGD (Figure 13). This demand decline occurred even with a growth in customers in already existing service areas, an expansion of the MWRA service area to include 6 more communities. In addition to water savings, the program also led to direct energy savings for the MWRA of 46.1 GWh, 6,983,000 Therms of natural gas per year, and 1,200 kW of avoided electricity capacity (Young, 2013).

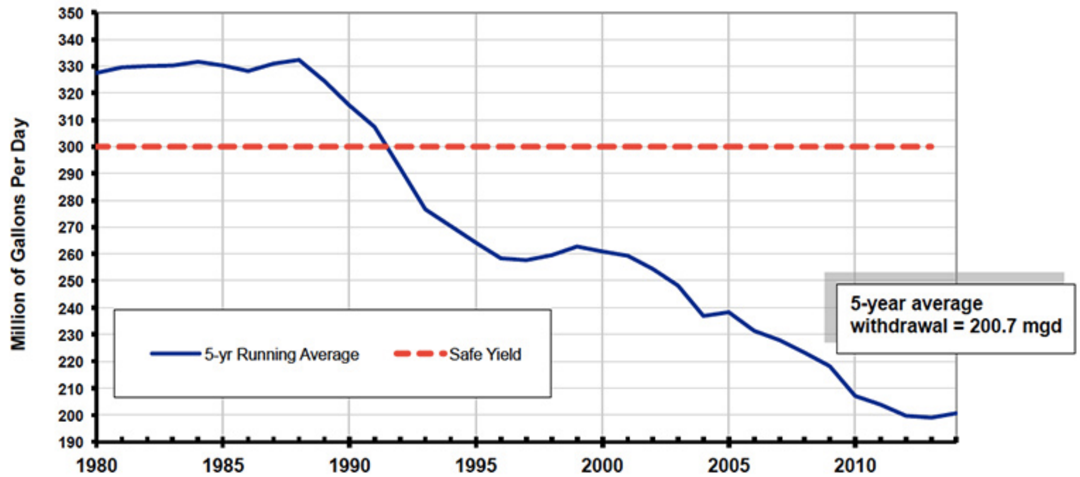

Figure 13 | MWRA Water Demand Reductions. MWRA, 2014

(2) *Mass Save Program*

a. In response to regulations put in place by the Green Communities Act, all IOU gas and electric utilities and energy efficiency service providers have partnered together to sponsor the Mass Save initiative. The program serves as a brand by the 11 IOUs in Massachusetts, and is supported by the MA Department of Energy Resources and the Energy Efficiency Advisory Council in order to synchronize program offerings, delivery models, application forms, and marketing plans. The program offers a range of DSM programs including outreach and educational programs about (California Sustainability Alliance, 2015) energy efficiency, rebates, home energy assessments, and direct installations.

The implementation of this program model has been an enormous coordination effort among utility PAs. While programs are consistent to all Massachusetts residents, PAs are regulated as individual program administrators and held accountable for individual goals and individual performance incentives. In order to address and effectively manages the differences in customer base that exist between PAs in terms of service territories and resource limitations, management teams were created that consisted of representatives from each PA. Management teams consisted of a commercial and industrial management committee, a residential management committee, and a low income management committee. In addition to each of these committees, an Evaluation Management Committee was created in order to identify and execute evaluation priorities, and identify further areas of research for DSM programs (Halfpenny, et al., 2012).

The statewide program has resulted in a major success and major challenges in regards to electricity savings, and coordination between PAs. The program has saved a total of 13,421,472 MWh, and 380,806,813 Therms since its inception, has provided in-home energy assessments and installments to all income levels and catalyzed the availability and affordability of LED lighting to commercial and industrial customers (Mass Save , 2015). Additionally, the PAs have also highlighted the benefits of sharing staffing and resources to the success of the program. PAs were able to pool resources, and hire one employee to facilitate managing meetings and develop new initiatives for all participating P.A.s. In addition to success, significant challenges have presented themselves throughout the execution of the program. The most significant challenge was establishing broad access to consistent statewide program data. Consistent reporting tables for the program had to be developed for each participating PA. The challenges for this lie in consistently providing program data without compromising customer privacy, or creating excessive administrative work for the PAs. As the Mass Save program continues, the success and challenges highlight that this collaborative approach to energy efficiency programs has opened the doors for additional opportunities to improve operating efficiencies for administering the program, and for having an even larger positive impact on the environment (Halfpenny, et al., 2012). An overview of joint programs in Massachusetts is provided in Table 5.

Program	Participating Utilities	Location	Regulatory Implications	Program Successes
Long Range Supply Program	Massachusetts Water Resources Authority	MA	Water Conservation Standards	Reduction in water demand from 340 MGD to 200 MGD
Mass SAVE	National Grid, Eversource, Berkshire Gas, Blackstone Gas, Capelight Compact, Liberty Utilities, Columbia Gas of MA, Unitil	MA	Green Communities Act	The program has saved 13,421,472 MWh, and 380,806,813 Therms since its inception

Table 5 | Massachusetts Joint Demand Side Management Programs

3.4 Research Question 4: Would greater collaboration be a way for California, Massachusetts, and other states to become more resilient to climate change?

3.4.1 National Climate Assessment Projections for the Southwest

Joint programs provide an opportunity for the United States water and energy sectors to be more resilient to the impacts of climate change. The National Climate Assessment provides a synthesis of the impacts that climate change will have on the different regions throughout the United States throughout the next century. California, being a part of the Southwest region is projected to experience increased heat, drought, wildfires and declining water supplies by 2050 (National Climate Assessment, 2014). As the hottest, and driest region of the United States, water availability has defined the landscapes, history of human settlement, and the modern economy. Human-induced climate change is expected to increase annual temperatures 2.5 to 5.5 degrees Fahrenheit by 2041-2070 (Figure 14) (National Climate Assessment, 2014).

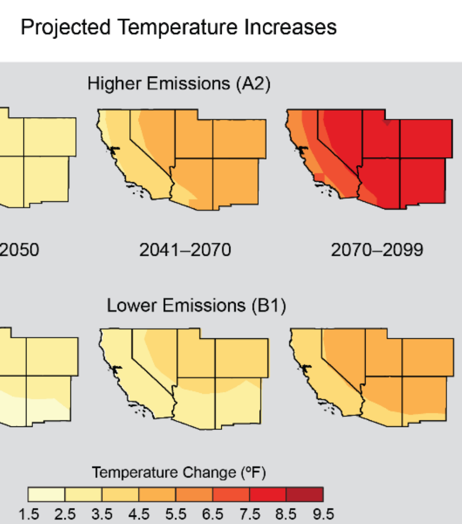

Figure 14 | Projected Temperature Increases in Southwest. National Climate Assessment, 2014

The presence of higher temperatures, and consequently more summer heat waves are projected to increase the risk of disruptions to electric power generation from high demand (National Climate Assessment, 2014). Although projections for precipitation changes are less certain than temperature, under current emission trends, continuous reductions in winter and spring precipitation are expected. Figure 15 displays the projected snow water equivalent for states throughout the Southwest.

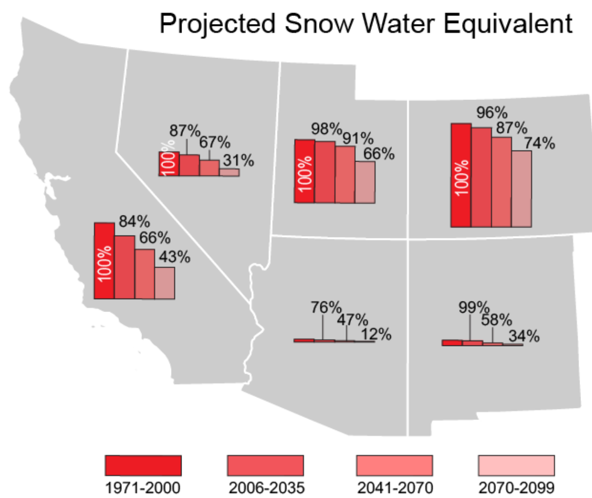

Figure 15 | Projected Snow Water Equivalent in Southwest. National Climate Assessment, 2014

As the Southwest becomes hotter, and drier, there will be less water available for the cooling of thermal power plants, which use about 40% of the surface water withdrawn in the United States (National Climate Assessment, 2014). Future projections for water and snowfall display the importance in DSM program collaboration for mitigating the impacts of climate change. In conjunction with conservation efforts, however, the emerging presence of wind and solar photovoltaic installations could also substantially reduce GHG emissions and water withdrawals. Figure 16 provides an illustrative scenario in which different energy combinations throughout the southwest could achieve an 80% reduction in GHG emissions by 2050 (National Climate Assessment, 2014). The energy mix varies by each state, and the circle represents the average hourly generation in megawatts from the potential energy sources.

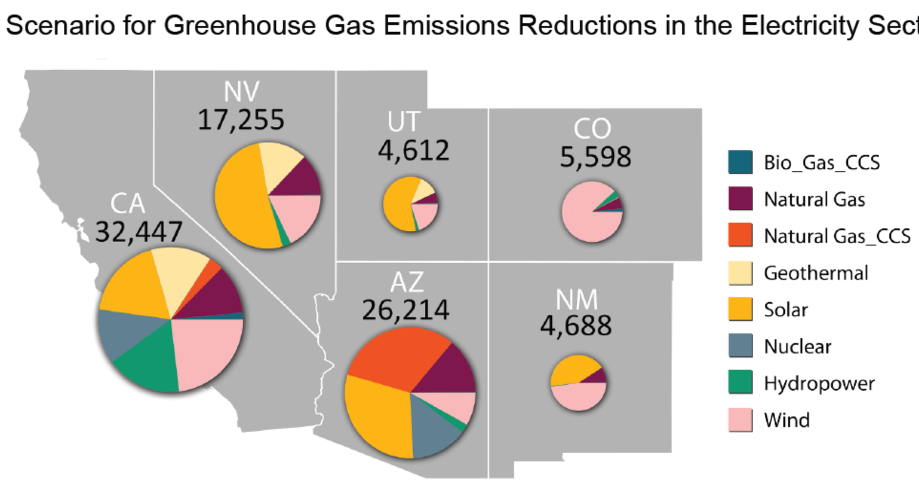

Figure 16 | Greenhouse Gas Emissions Reductions Scenario. National Climate Assessment, 2014

3.4.2 National Climate Assessment Projections for the Northeast

While the Northeast does not experience the water resource constraints of the Southwest, the region is expected to experience warming temperatures and increased extreme weather (National Climate Assessment, 2014). The amount of warming in the Northeast will be highly dependent on global greenhouse gas emissions. If emissions continue to increase at the A2 scenario rate a warming 4.5 to 10 degrees Fahrenheit is projected by the 2080s. If global emissions are reduced at the B1 scenario rate, projected warming will range from 3 to 6 degrees Fahrenheit. Under both scenarios, the frequency, and intensity of heat waves is expected to increase. Figure 17 displays projections under each scenario in number of days above 90 degrees between 2041 and 2070 (National Climate Assessment, 2014).

Projected Increases in the Number of Days over 90°F

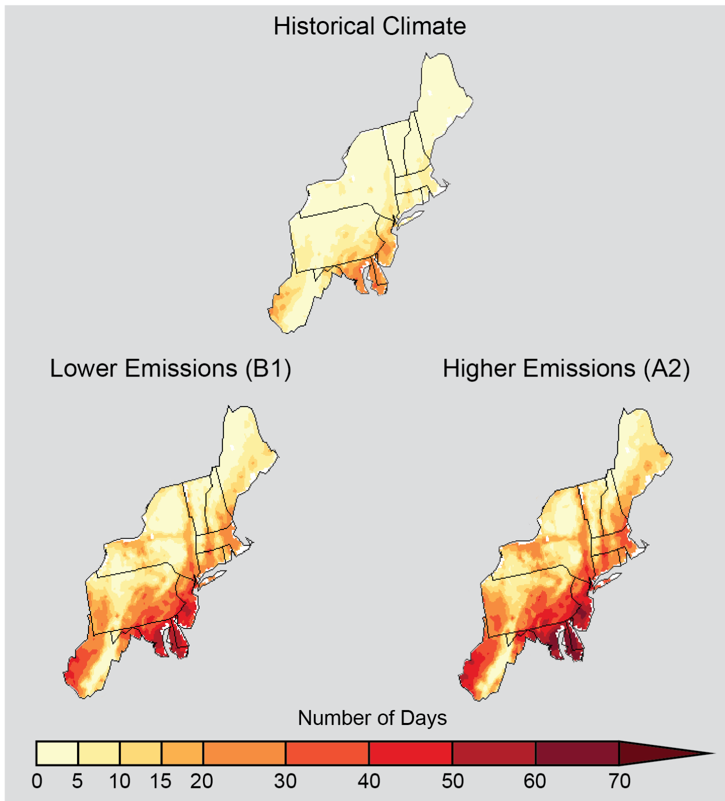

Figure 17 | Projected Increase in Number of Days over 90 Degrees Fahrenheit. National Climate Assessment, 2014

Northeast precipitation projections are expected to increase in the northeast region. The A2 scenario suggests that a 5% to 20% increase in winter precipitation (National Climate Assessment, 2014). Global sea levels are also projected to rise 1 to 4 feet by 2100, from melting ice sheets in Greenland. With 1.6 million people in the northeast living within the Federal Emergency Management Agency's (FEMA) 100-year coastal flood zone, this puts a large percentage of the population at risk (National Climate Assessment, 2014). More severe weather patterns, such as hurricanes, have also posed considerable vulnerability to urban infrastructure in the Northeast. In regards to the water and energy sectors, devastation from severe weather can lead to damaged energy infrastructure (such as thermoelectric power plants and nuclear facilities), and backup of combined sewer systems that collect and treat both storm water and municipal wastewater. Although the northeast is not a stressed region for water resources, if average temperatures increase as projected, the region will be susceptible to sea level rise and extreme weather events that could impact water and energy system infrastructure. Additionally, increasing heat waves will create a larger demand on the grid system which can lead to disruptions in electric power generation (National Climate Assessment, 2014).

Resource conservation through joint water and energy DSM programs will provide cost-effective way of reducing demand of both resources, and therefore increasing resiliency for both regions of the United States. While joint programs provide one method of increasing resiliency, larger changes to our energy and water sector infrastructure, such as integrating renewable energy, and improving water pipelines, storm water management systems, and water treatment facilities will be crucial as resources are constrained, and extreme weather events become increasingly common.

4.0 Conclusions

Improving energy and water efficiency is a cost-effective way to reduce water use in the power sector and reduce energy use by water and wastewater utilities. Water consumption requires watts of electricity in order to collect, transport, and treat that water. Similarly, every watt of thermal-powered electricity consumed is created through the use of needed water for the cooling process. Collaboration between water and energy utilities provides an opportunity to reduce the water and energy intensity of each of theses processes. Each sector, however, operates under vastly differing regulatory structures, which serve to limit collaboration. Increased federal and state-level policies for energy efficiency, water conservation, and greenhouse gas emissions, however, have catalyzed the presence of energy efficient technologies, and has pushed each sector to develop innovative programs in order to meet policy standards.

Joint program collaboration provides utilities with the ability to obtain a greater benefit per customer by reducing the staff time required to administer the programs. Additionally, joint programs provide a means to increase cross-sector knowledge of the relationship between water and energy through sophisticated tracking and evaluating. Limited, but successful programs in California and Massachusetts highlight the opportunities where joint programs can make business sense for utilities, and spur greater resource savings. Furthermore, joint programs are a cost-effective way to reduce demand for each respective resource, and increase climate change resilience throughout the different regions of the United States.

5.0 Recommendations

In order to develop effective cross-sector programs, the recommendations below provide a synthesis of best practices moving forward based on the state of the regulatory framework, barriers and benefits, the case studies analyzed, and climate change implications.

(1) Designate a staff member to lead efforts for pursuing water-energy program opportunities

One of the top barriers to coordinated programs, according to the Pacific Institute is limited staff time (Cooley & Donnelly, 2013). *Both water and electric utilities suffer from staff constraints when administering efficiency programs in order to meet state regulations. Efficiency programs, however, often have overlapping administrative tasks and overlapping efficiency goals that provide an opportunity for streamlining the process, and dedicating resources from each utility. To optimize staff resources, joint programs can be streamlined through the creation of a Master Inter-Utility Agreement (MIUA), which clearly defines roles and responsibilities between utilities in regards to program administration. The success of the agreement between Southern California Gas Company and LADWP highlights the success of developing an MIUA to either define goals and responsibilities for a specific joint program, or for developing a long-term collaboration between sectors. Additionally, partnerships between utilities can potentially reduce overall program costs and staffing resources needed for administration. The high-efficiency clothes washer rebate program between Bay Area water agencies and PG&E proved to be more cost-effective through collaboration of staffing resources than running two parallel rebate programs.*

(2) Consider using a third-party to administer the program to reduce the burden on staff time

Although joint programs can reduce staff time and resources needed from each participating utility, utilizing a third-party contractor to administer the program can be an easier method of coordinating joint programs. The success of the Mass Save program in Massachusetts, and SDG&E and SDCWA partnership in California highlight *that third-party contractors can be a less time intensive option for utilities, but still offer the desired water and energy savings.*

(3) State agencies should develop guidelines for allocating water, energy and cost savings among project partners.

One of the most significant components to coordinated water energy programs is federal and state policies that guide utilities to implement the needed changes in order to reduce the impacts of the water-energy nexus moving forward. Moving forward, state agencies should work to develop guidelines for developing efficiency programs across sectors, options for grants and funding, and rules and regulations for allocating responsibilities between participating utilities, and for tracking cost and resource savings throughout the duration of the program.

(4) Identify and streamline the process for tracking both energy and water savings to further inform water-energy nexus decisions

In addition to the challenges to program facilitation across sectors comes the challenge of tracking data in order to monitor the water and energy intensity of end-use activities and further understanding of the water-energy nexus. Smart technologies currently being developed and implemented throughout both the water and energy sectors provide viable solutions to the insufficiency of data currently available. Smart technologies are able to track water or energy use from end-use, consumer activities. The WaterSmart Landscape Efficiency Program between SDCWA and SDG&E was able to successfully track water and energy use data through self-reported data from each program participant through the use of smart technologies.

6.0 Limitations and Future Work

Limitations of this study include the use of secondary data sources to analyze the success of coordinated programs, and the lack of available data in regards to exactly how much water is used in the energy sector, and how much energy is used in the water sector throughout the United States. This is a rapidly evolving area of research and there are significant gaps in literature in regards to detailed data on the water-energy nexus, and examples of collaborative programs and associated savings for those programs. A database that includes detailed state-level information on water and energy consumption, implemented demand-side management programs, and the intricacies of how program administrators determined how to budget and distribute responsibilities could be a critical resource moving forward.

There are also opportunities for analysis of how emerging renewable energy resources will impact the water-energy nexus. As the market moves away from a fossil-fuel based energy system, the relationship between the sectors and resource consumption will change. Research that determines how much water is used in both production of renewable energy materials, and the energy generation process will be important data to take into consideration moving forward.

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