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POWERING THE TAP DRY: REGULATORY ALTERNATIVES FOR THE ENERGY-WATER NEXUS

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In 2008, while Atlanta residents freely watered their lawns, several nuclear power plants in Georgia almost shut down due to drought-induced water scarcity. This absurd reality stemmed from the misunderstood and almost wholly unregulated relationship between energy and water. Water and energy are indivisibly linked and interwoven into every aspect of our culture and lifestyle. Large quantities of water are required to generate energy, and energy is required at all stages of the water supply process including pumping, treating, and end uses. While much has been written recently on the numeric relationship between these sectors, little has been proposed from the legal and policy community regarding regulations to avoid future conflicts between the sectors. The regulatory solution to this problem is multifaceted. At the outset, mandatory data collection and sharing should be increased and standardized in both sectors. Energy- and water-efficient technologies need to be encouraged and incentivized by all levels of government. Maximizing the efficiency of both the water and power sectors can be accomplished by expanding existing federal and state programs and through additional regulatory requirements. As the stress to water and energy resources increases, the urgency of proper planning also grows. The era of bifurcated planning is outdated; therefore, both federal and state governments should require consideration

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of the water demands when planning new energy technologies and projects, and vice versa. Integration of sector planning is critical to energy and water security and sustainability.

INTRODUCTION

In 2008, several nuclear power plants in the southeastern United States almost shut down because water temperatures were too high to cool the plant or water levels dropped beneath intake pipes all together.[1] Both of these problems were caused by drought-induced water shortages.[2] Meanwhile, Atlanta's residents continued to water their lawns without restriction.[3]

1. *Drought Could Shut Down Nuclear Power Plants*, NBCNEWS.COM (Jan. 23, 2008), http://www.msnbc.msn.com/id/22804065/ns/weather/t/drought-could-shut-down-nuclear-power-plants/ [hereinafter *Drought*]. There were three million customers who received power from reactors in the drought zone. *Id.*

2. *Id.*

3. *See* Brenda Goodman, *Drought-Stricken South Facing Tough Choices*, N.Y. TIMES, Oct. 16, 2007, http://www.nytimes.com/2007/10/16/us/16drought.html; Brian Clark Howard, *No Solution to Drought in Sight: Atlanta Water Czar*, DAILY GREEN (Dec. 12, 2007), http://www.thedailygreen.com/green-homes/

This absurd reality existed because water and power generation are not regulated in tandem. While much has been written recently on the scientific relationship between these sectors,[4] little has been proposed from the legal and policy communities regarding how to remedy these issues. The regulatory solution to this problem is multifaceted. At the outset, mandatory data collection and sharing should be increased in both sectors. Additionally, energy- and water-efficient technologies need to be encouraged and incentivized. And finally, both federal and state governments should require consideration of the water demands of new energy technologies and projects, and vice versa.

Water and energy are indivisibly linked and interwoven into every aspect of our culture and lifestyle. From flipping on the lights or turning on the tap to starting our cars, one sector impacts the other. Energy is required at all stages of the water supply process including pumping, treating, and end use. Four percent of national energy requirements are used to move and treat water and wastewater.[5] Water utilities are often a city's largest electric customer, with water and wastewater treatment comprising 30 to 50 percent of the city's energy bill.[6] In the home, heating water can account for 30 percent of municipal energy costs.[7]

Similarly, the power sector requires large quantities of water.[8] Thermoelectric generation constitutes 87 percent of the United States' energy portfolio.[9] Nationally, 41 percent of all freshwater withdrawals in 2005 were for thermoelectric power

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eco-friendly/southeast-drought-altanta-water-woes-461212.

4. *See, e.g.*, U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-11-225, ENERGY-WATER NEXUS: AMOUNT OF ENERGY NEEDED TO SUPPLY, USE, AND TREAT WATER IS LOCATION-SPECIFIC AND CAN BE REDUCED BY CERTAIN TECHNOLOGIES AND APPROACHES (2011); KRISTIN GERDES & CHRISTOPHER NICHOLS, NAT'L ENERGY TECH. LAB., WATER REQUIREMENTS FOR EXISTING AND EMERGING THERMOELECTRIC PLANT TECHNOLOGIES 3 (2009), http://www.netl.doe.gov/energy-analyses/pubs/WaterRequirements.pdf.

5. Jess Chandler et al., *Water and Watts*, SE. ENERGY OPPORTUNITIES, Apr. 2009, at 1, http://pdf.wri.org/southeast_water_and_watts.pdf.

6. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 17.

7. Chandler et al., *supra* note 5, at 1.

8. *See* ASHLYNN S. STILLWELL ET AL., ENERGY-WATER NEXUS IN TEXAS 28 (2009), http://www.edf.org/sites/default/files/Energy_Water_Nexus_in_Texas_1.pdf.

9. *Electricity Explained: Electricity in the United States*, ENERGY INFO. ADMIN., http://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states (last updated May 2, 2012). Of this total, coal is 42 percent, natural gas is 25 percent, nuclear is 19 percent, and petroleum is less than 1 percent. *Id.* The remaining 13 percent is made up of renewables and hydroelectric power. *Id.*

generation.[10] The total withdrawals for thermoelectric power generation were 3 percent larger in 2005 than 2000; total freshwater withdrawals increased by 7 percent and will continue trending upward if more traditional power generation is constructed to meet growing populations' needs.[11] Globally, energy demand is projected to increase over 50 percent in less than twenty years.[12]

Historically, the water and power sectors were planned separately. Despite the large water requirements of power plants, water was seldom a factor in locating or permitting new plants.[13] Other factors such as land prices and proximity to coal seams, rail lines, and power lines far exceeded water in importance.[14] In spite of their mutual reliance, infrastructure for each was designed and built without reference to the other. Although this did not originally create significant challenges, increased demand created by population growth shifting to urban areas coupled with unpredictable weather patterns, such as widespread droughts, reduced communities' resilience in times of stress.[15]

"Even under normal conditions, water managers in [thirty-six] states anticipate shortages in localities, regions, or statewide in the next [ten] years. Drought conditions will

10. JOAN F. KENNY ET AL., U.S. GEOLOGICAL SURVEY, CIRCULAR 1344, ESTIMATED USE OF WATER IN THE UNITED STATES IN 2005, at 38 (2009), http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf. Power-related water withdrawals were 49 percent of total water use. *Id.* at 5. Irrigation constituted 31 percent of withdrawals. *Id.* This represents a shift from 1995 statistics when agricultural withdrawals were greater than the electric industry (39 percent). *Compare id.*, *with* THOMAS J. FEELEY & MASSOOD RAMEZAN, ELECTRIC UTILITIES AND WATER: EMERGING ISSUES AND R&D NEEDS 2 (2003). The average total consumptive use of water in United States' thermoelectric power plants is 0.47 gallons (1.8 L) per kilowatt-hour (kWh). P. TORCELLINI ET AL., NAT'L RENEWABLE ENERGY LAB., CONSUMPTIVE WATER USE FOR U.S. POWER PRODUCTION 4 (2003), http://www.nrel.gov/docs/fy04osti/33905.pdf. In Texas, 2005's power generation was 43 percent of withdrawals, considerably more than the 29 percent withdrawn for agriculture. *See* KENNY ET AL., *supra* note 10, at 8.

11. *See* KENNY ET AL., *supra* note 10, at 38.

12. WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., WATER, ENERGY AND CLIMATE CHANGE 2 (2009), http://www.c2es.org/docUploads/WaterEnergyand ClimateChange.pdf.

13. CLEAN AIR TASK FORCE & THE LAND AND WATER FUND OF THE ROCKIES, THE LAST STRAW: WATER USE BY POWER PLANTS IN THE ARID WEST 6 (2003), http://www.catf.us/resources/publications/files/The_Last_Straw.pdf.

14. *See, e.g.*, Emily A. Peters, *Tenaska Drops Abilene Water Request, Outlines Other Sources*, ABILENE REP.-NEWS (July 1, 2010), http://www.reporternews.com/news/2010/jul/01/tenaska-withdraws-abilene-water-request/.

15. *See, e.g.*, Goodman, *supra* note 3.

exacerbate shortage impacts."[16] Freshwater withdrawals in developed countries are predicted to increase 18 percent over the next thirteen years.[17] "Climate change acts as an amplifier of the already-intense competition over water and energy resources."[18] The failure of policymakers to recognize the impact of one industry on the other can create major shortfalls in both.

A frequently cited example of this collision point occurred during the 2008 drought in the southeastern United States.[19] This region had always considered itself to be water rich so long-term water planning was not a concern.[20] Suddenly, the rain stopped while pumping continued to soar to meet domestic and power needs.[21] Large cities like Atlanta never implemented comprehensive water conservation or drought plans, which nearly caused catastrophic consequences when people were still allowed to water their lawns even though water resources reached record lows and power plants were almost forced to stop functioning.[22] Even states well acquainted with drought have not planned as effectively as they should.[23] For example, in Texas, cities with extensive water conservation and drought plans frequently do not refer to energy, and their energy plans likewise do not refer to water planning.[24]

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16. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-03-514, FRESHWATER SUPPLY: STATES' VIEWS OF HOW FEDERAL AGENCIES COULD HELP THEM MEET THE CHALLENGES OF EXPECTED SHORTAGES (2003), http://www.gao.gov/assets/160/157452.pdf.

17. WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., *supra* note 12, at 2; *see also* Steve Kellman, *America's Water Supply: Scarcity Becoming Endemic*, CIRCLE OF BLUE (Oct. 12, 2009), http://www.circleofblue.org/waternews/2009/world/america%E2%80%99s-water-supply-scarcity-becoming-endemic/ (demonstrating how current withdrawals are already creating challenges in western state).

18. WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., *supra* note 12, at 3.

19. *See* Larry Copeland, *Drought Spreading in Southeast*, USA TODAY (Feb. 12, 2008, 11:52 AM), http://www.usatoday.com/weather/drought/2008-02-11drought_N.htm.

20. *See* Chandler et al., *supra* note 5, at 3. The population of the southeastern U.S. has increased almost 20 percent in the last decade. *Id.*

21. *See supra* notes 1, 5 and accompanying text.

22. *See* Copeland, *supra* note 19.

23. *See, e.g.*, Ryan Murphy, *Interactive Map: Texas Cities at Risk of Running Out of Water*, TEX. TRIB. (Nov. 13, 2011), http://www.texastribune.org/library/data/tceq-high-priority-water-locations/.

24. *See* SAN ANTONIO, TEX., CODE OF ORDINANCES ch. 34, art. IV §§ 34-271 to -425 (2012). Recently, the first joint board meeting was held between San Antonio's water and electric utilities in an effort to capture these linkages in their respective programs. *SAWS, CPS Energy Highlight Water-Energy Nexus at First Joint Board Meeting*, SAN ANTONIO WATER SYS. (Apr. 8, 2011), http://www.saws.org/latest_news/Newsdrill.cfm?news_id=750. In addition, a new

The era of bifurcated planning is outdated. As the stress to water and energy resources increases, the urgency of proper planning also grows. Federal agencies such as the Department of Energy (DOE), the National Renewable Energy Laboratory (NREL), and the Government Accountability Office (GAO), as well as state planning agencies, are recognizing the need to better understand the relationship between water and energy.[25] Beyond understanding the data, policies need to be implemented at the federal, state, and local levels to ensure proper data collection and evaluation as well as coordinated sector planning.

This paper proposes policy initiatives at the federal, state, and local levels that clarify and regulate the relationship between energy and water and that would increase energy and water security. Part I gives a brief description of the physical relationship between the two sectors to elucidate the magnitude of this challenge. Part II describes the limited policy initiatives that have been proposed or implemented to achieve the goal of data gathering or sustainability. Part III lists and describes policy alternatives ranging from incentivizing well-demonstrated conservation and efficiency programs, to more complex initiatives that would coordinate planning of both sectors to avoid unintended consequences and fill data gaps. These proposed policies include uniform, standardized reporting of complete water use at power plants to ensure accuracy of technologies comparisons planning. This paper concludes that some policy alternatives are better suited at the federal level while others are more appropriate on the state or even local level. Joint implementation of a suite of these options would increase sustainability and security in both sectors.

I. THE ENERGY-WATER NEXUS BY THE NUMBERS

Understanding the solution is predicated on understanding the situation. One of the largest challenges to promulgating

smart grid project in Austin, Texas called the Pecan Street Project is unique because water saving programs, such as smart water meters and smart irrigation systems, were included based on encouragement from participating nonprofits. *See* THE PECAN STREET PROJECT, WORKING GROUP RECOMMENDATIONS 11, 15 (Mar. 2010), http://www.pecanstreet.org/wordpress/wpcontent/uploads/2011/08/Pecan_Final_Report_March_2010.pdf.

25. *See generally, e.g.*, CAREY KING ET AL., WATER DEMAND PROJECTIONS FOR POWER GENERATION IN TEXAS (2008).

rules and regulations is the need to increase awareness of the physical relationship between energy and water. Appreciation of the numbers can prompt policy makers to move forward in joining these sectors and allow policy to more closely track the real-world situation.

First, the amount of water used for power generation must be quantified and reported. Necessary amounts can vary depending on location and the cooling technology utilized. Similarly, the energy needed for the various stages of the water lifecycle must be measured and available. In addition to water for energy production, this Part discusses other aspects of energy creation, including gas production and post-combustion technologies, which can also have substantial water footprints. While evaluating these relationships, it becomes clear that significant amounts of data are not available for consideration, thwarting our full understanding of the energy-water relationship.

A. *Power Sector*

The power sector has a significant impact on water usage. Thermoelectric power plants use water to cool the steam that turns the electricity-generating turbine.[26] Included within this oversimplified engineering description are a variety of technologies that use a range of water quantities.[27] Overall, the power sector accounts for 49 percent of all national water withdrawals, or 201 trillion gallons per day.[28] Maintaining power throughout the United States requires the same amount

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26. These are primarily power plants that are fueled by fossil fuels, nuclear or geothermal, but can also include collective solar. *See* STILLWELL ET AL., *supra* note 8, at 12. Hydroelectric facilities consume large amounts of water through evaporation. *See* TORCELLINI ET AL., *supra* note 10, at 9. An average hydroelectric plant evaporates an average of eighteen gallons of water per kWh used by the consumer. *Id.* at iv.

27. *See* STILLWELL ET AL., *supra* note 8, at 12.

28. KENNY ET AL., *supra* note 10, at 38. Of this total, only 1.96 trillion gallons were from groundwater sources, but this number may increase as surface water sources become more limited. *Id.* at 38–39. In the southeastern U.S., two-thirds of all freshwater withdrawals are for power generation, equaling approximately 40 billion gallons of water daily. UNION OF CONCERNED SCIENTISTS, THE ENERGY-WATER COLLISION: 10 THINGS YOU SHOULD KNOW 1 (2010), http://www.ucsusa.org/assets/documents/clean_energy/10-Things.pdf; Chandler et al., *supra* note 5, at 1. This is equivalent to the amount of water used for the United States' entire daily public water supply. Chandler et al., *supra* note 5, at 2. Agricultural irrigation accounts for 37 percent of U.S. withdrawals, the majority of which is consumptive. UNION OF CONCERNED SCIENTISTS, *supra* note 28, at 2.

of water as the population of 140 New York Cities.[29]

To understand the power sector's impact on water usage, it is important to distinguish between withdrawal and consumption of water. Withdrawal refers to water removed from the ground or diverted from a water source for cooling and other purposes.[30] This water is returned to the source after use.[31] Consumption refers to water that is lost through evaporation, transpiration, or otherwise removed from the immediate water environment and consequently not available for reuse.[32] Even cooling technologies that depend primarily on withdrawing and returning water incur some percentage of water consumption through evaporation.[33]

For water resource planning purposes, consumption is often viewed as more problematic than withdrawal, particularly in water-constrained regions;[34] however, this does not mean that withdrawn water does not have an effect. If a quantity of water is being withdrawn for a power plant, it cannot be utilized for other purposes for some period of time before it is returned to the source.

These plants can also have significant environmental impacts. Power plant intake structures often kill large numbers of fish.[35] In addition, drawing down water resources

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29. UNION OF CONCERNED SCIENTISTS, *supra* note 28, at 1. In addition to generation, water is generally needed for mining and transporting the fuel. *See, e.g.*, *How It Works: Water for Coal*, UNION OF CONCERNED SCIENTISTS, http://www.ucsusa.org/clean_energy/our-energy-choices/energy-and-water-use/water-energy-electricity-coal.html (last visited Nov. 30, 2012). The actual amount is dependent on several factors including fuel type and location of extraction. For example, open pit coal mining requires 528 gallons of water per 1,000 GJ, whereas underground mining can require up to 5,000 gallons for the same amount of energy. WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., *supra* note 12, at 16.

30. KENNY ET AL., *supra* note 10, at 49.

31. Evaporation may occur after the water is returned to the source and the quality of the return water can also have ecological impacts. *See* GERDES & NICHOLS, *supra* note 4, at 3.

32. KENNY ET AL., *supra* note 10, at 47.

33. *See* STILLWELL ET AL., *supra* note 8, at 12.

34. *See, e.g.*, Robin Madel, *Water Use, Withdrawal and Consumption: What Does It All Mean?*, ECOCENTRIC BLOG (Aug. 24, 2010), http://www.ecocentricblog.org/2010/08/24/water-use-withdrawal-and-consumption-what-does-it-all-mean/.

35. *See Justices Join Debate Over Power Plants, Fish Kills*, NBCNEWS.COM (Oct. 18, 2008), http://www.msnbc.msn.com/id/27251643/ns/us_news-environment/t/justices-join-debate-over-power-plants-fish-kills/; *see also Power Plant Fish Kills*, RIVERKEEPER, http://www.riverkeeper.org/campaigns/stop-polluters/power-plants/power-plant-fish-kills/ (last visited Nov. 18, 2012) (explaining that a large portion of the Hudson River's organisms are killed through the annual withdrawal of 1.2 trillion gallons of water by power plants). As a result of a consent decree with environmental groups, the EPA recently proposed a rule change under section

can cause water temperatures to increase, which can be deadly for aquatic life and threaten whole ecosystems.[36] Similarly, many power plants discharge cooling water at high temperatures, thereby creating additional issues for fish and aquatic species.[37] The decrease of water quantity means the water body may not be able to ameliorate this issue through dilution.

Cooling technology plays a large part in determining how much water a power plant uses.[38] Similar cooling technologies are used by coal, gas, nuclear, and large-scale concentrated solar power plants with some water variation rates based on fuel choice.[39] There are three basic types of cooling technologies: open-loop, closed-loop, and dry or air cooling. The technology with the largest water withdrawal demand is open-loop cooling, also called "once-through" cooling.[40] Open-loop systems use water stored nearby, often in cooling ponds or rivers, to cool discharged condenser water.[41] The exiting water is then pumped back through the cycle and returned to the source.[42] This technology withdraws large amounts of water because water only passes through the system a single time.[43] Ninety-two percent of all power-related withdrawals are for plants with open-loop cooling systems.[44]

In comparison to open-loop cooling, recirculated or closed-

316(b) of the Clean Water Act (CWA) to reduce the impacts of once-through cooling by setting a performance standard for fish mortality due to impingement. National Pollutant Discharge Elimination System—Cooling Water Intake Structures at Existing Facilities and Phase I Facilities, 76 Fed. Reg. 22174 (proposed Apr. 20, 2011) (to be codified at 40 C.F.R. pts.122, 125) [hereinafter National Pollutant Discharge Elimination System]. These standards would apply to new and existing facilities and can be met by withdrawing less water (such as ending once-through cooling) or changing the rate of withdrawal. *Id.* *See also* discussion *infra* Part II.B.

36. *See* GEORGE W. LEWIS, DROUGHT CONDITIONS WHICH AFFECT FISH & PONDS: HEAT, DROUGHT AND OTHER PROBLEMS, http://warnell.forestry.uga.edu/service/library/wsfr-001/wsfr-001.pdf.

37. *Drought*, *supra* note 1.

38. *See* JORDAN MACKNICK ET AL., NAT'L RENEWABLE ENERGY LAB., A REVIEW OF OPERATIONAL WATER CONSUMPTION AND WITHDRAWAL FACTORS FOR ELECTRICITY GENERATING TECHNOLOGIES, at iv (2011), http://www.nrel.gov/docs/fy11osti/50900.pdf. Other factors that can impact water use, which will not be discussed in this paper, include plant location, age of the plant, thermal efficiency, and the water source. *Id.* at 3.

39. *See* STILLWELL ET AL., *supra* note 8, at 12.

40. *Id.* at 6–9.

41. *See* TORCELLINI ET AL., *supra* note 10, at 9.

42. *Id.*

43. STILLWELL ET AL., *supra* note 8, at 7.

44. KENNY ET AL., *supra* note 10, at 38.

loop cooling brings in cooling water from a source and once water exchanges heat in a heat exchanger, the cooling water is recycled between a cooling tower and heat exchanger.[45] Each time the cooling water is cooled, a percentage of water is lost through evaporation.[46] Additional water is then brought in to account for the consumed water.[47] By recycling the water, this system minimizes the water withdrawn, but has higher consumptive rates than the open-loop cooling system. Open-loop cooling withdraws ten to one hundred times more water per unit of electric generation than plants that reuse the water in the system, but consumes half as much water per unit generated.[48] The current trend in new plants is to install recirculating systems; some states are even considering a prohibition on once-through systems.[49]

Finally, dry cooling uses air rather than water to cool the steam, bringing water withdrawals and consumption to almost zero.[50] The drawback to this cooling technology is that it reduces the efficiency of the plant up to 25 percent in hot weather, which is often when the power is most needed.[51] Closed-loop systems are approximately 40 percent more expensive than open-loop cooling, and dry cooling systems are three to four times more expensive than closed-loop systems.[52] Due to these challenges, dry cooling is utilized less often; however, it is becoming more common because sufficient water for other technologies is not available.[53] The lowest overall water consumption numbers in power production are from wind energy, solar photovoltaic, and natural gas facilities that

45. TORCELLINI ET AL., *supra* note 10, at 10.

46. *Id.*

47. *Id.*

48. *See* MACKNICK ET AL., *supra* note 38, at 6.

49. *See, e.g.*, *Coastal Resources: Once-Through Cooling*, TOTALCAPITOL.COM (2012), http://totalcapitol.com/?bill_id=200920100SB42 (proposing a ban on once-through cooling); *see also* discussion *infra* Part II.B.

50. *See* Riley Wyman, *Dry-Cooling Power Plants to Reduce Water Consumption*, *in* 10 IDEAS FOR ENERGY & THE ENV'T 20–21 (2010), *available at* http://www.scribd.com/doc/34735540/Dry-Cooling-Power-Plants.

51. MARTIN J. PASQUALETTI & SCOTT KELLEY, THE WATER COSTS OF ELECTRICITY IN ARIZONA: EXECUTIVE SUMMARY 4 (2008), http://www.azwater.gov/AzDWR/StatewidePlanning/Conservation2/Documents/documents/TheWaterCostsofElectricityinArizona.pdf.

52. GERDES & NICHOLS, *supra* note 4, at 5.

53. *See, e.g.*, Doug Myers, *Tenaska Chooses Cooling Method that Requires Lower Amount of Water*, ABILENE REP.-NEWS (Apr. 6, 2010), http://www.reporternews.com/news/2010/apr/06/tenaska-chooses-cooling-method-requires-lower-amou/ (announcing the use of dry cooling because of limited available water resources).

employ dry cooling technologies.[54]

Fuel type can also affect the amount of water withdrawn and consumed. The fuel with the highest withdrawal rates is nuclear, which requires up to sixty thousand gallons/megawatt hour (gal/MWh) for a once-through system.[55] The maximum consumption rate for the same technology is four hundred gal/MWh.[56] A traditional coal-fired power plant using once-through cooling withdraws at most fifty thousand gal/MWh, but consumes 317 gal/MWh.[57] Each coal-generated kilowatt hour of electricity requires approximately twenty-five gallons of water to produce.[58] Natural gas uses considerably less water with a maximum withdrawal rate of twenty thousand gal/MWh and one hundred gal/MWh consumption.[59]

The high water demand of power generation often sets the water and power industries on a collision course, particularly in low-water years.[60] Since 2004, water shortages have caused the temporary reduction or entire shut down of at least a dozen power plants.[61] Several states have rejected proposed power

54. *See* MACKNICK ET AL., *supra* note 38, at 11.

55. *Id.* at 11, 13–14.

56. *Id.* The average nuclear withdrawal rate for once-through is 44,350 gal/MWh and consumption is 269 gal/MWh. *Id.* In 2008, twenty-four of the nation's 104 nuclear reactors were in areas of severe drought. *Drought*, *supra* note 1.

57. *See* MACKNICK ET AL., *supra* note 38, at 13–14. The average coal withdrawal rate for once-through is 36,350 gal/MWh and consumption is 250 gal/MWh. *Id.*

58. ERIK SHUSTER & JEFFREY HOFFMANN, NAT'L ENERGY TECH. LAB., WATER REQUIREMENTS FOR FOSSIL-BASED ELECTRICITY PLANTS WITH AND WITHOUT CARBON CAPTURE 1 (2009).

59. *See* MACKNICK ET AL., *supra* note 38, at 13–14. The average gas combined cycle withdrawal rate for once-through is 11,380 gal/MWh and consumption is 100 gal/MWh. *Id.*

60. Many regions are forecasted to have water shortages even under normal conditions. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 16, at 8. This is already a recurring issue in the American Southwest, where the population continues to grow. *See* Felicity Barringer, *Water Use in Southwest Heads for a Day of Reckoning*, N.Y. TIMES, Sept. 27, 2010, http://www.nytimes.com/2010/09/28/us/28mead.html. The impact of these shortages will be particularly acute in U.S. cities. Benjamin K. Sovacool, *Running on Empty: The Electricity-Water Nexus and the U.S. Electric Utility Sector*, 30 ENERGY L.J. 11, 24 (2009) (listing the twenty U.S. metropolitan areas most at risk for water shortages caused by the thermoelectric industry).

61. UNION OF CONCERNED SCIENTISTS, *supra* note 28, at 2. Limitations on generation due to water issues can be due to lack of sufficient water for cooling, or reduced water resources becoming too warm to successfully cool the turbine. *See Drought*, *supra* note 1. Ironically, these forced reductions usually occur during hot weather when power demand is even higher than normal. *See* Sovacool, *supra* note 60, at 23.

plants based on the lack of available water.[62] In addition to lacking adequate supplies, shortages increase the potential for transboundary conflicts.[63] Without policy changes, the energy security of the United States and the sustainability of its communities are threatened.[64] Similar challenges exist in ensuring sufficient energy supplies for all uses, including the water supply chain.

B. *Water Supply*

On the water supply side, energy is used at every stage of the water life cycle.[65] Energy is used to extract water from its source,[66] treat it to the appropriate standards,[67] move it to its intended location,[68] heat it,[69] and treat the wastewater before it is discharged back into the environment.[70] In total, 3 to 4 percent of national energy requirements are used to move or

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62. Sovacool, *supra* note 60, at 12–13. Proposed power plants in Texas have been met with resistance on water issues with citizens' concerns that power needs will be pitted against agricultural needs. Fernando Castro, *Residents Talk Water Loss Issues*, THE COLORADO COUNTY CITIZEN (May 10, 2011), http://www.coloradocountycitizen.com/news/article_e8684fc4-7b29-11e0-adc5-001cc4c002e0.html; *see also* Anton Caputo & Asher Price, *Water Issue Heats up Nuclear Power Debate*, AUSTIN AM.-STATESMAN, Sept. 13, 2009, at B1, 6.

63. *See, e.g.*, *Alabama, Florida and Georgia: A Tri-State Tug-of-War for Lake Lanier*, CIRCLE OF BLUE (Oct. 12, 2009), http://www.circleofblue.org/waternews/2009/world/alabama-florida-and-georgia-a-tri-state-tug-of-war-for-lake-lanier/; *Georgia and Tennessee: 200 Years of a Tennessee River Toss-up*, CIRCLE OF BLUE (Oct. 12, 2009), http://www.circleofblue.org/waternews/2009/world/georgia-and-tennessee-200-years-of-a-tennessee-river-toss-up/; *Nevada and Utah: Desert Aquifer Dispute in Snake Valley*, CIRCLE OF BLUE (Oct. 12, 2009), http://www.circleofblue.org/waternews/2009/world/nevada-and-utah-desert-aquifer-dispute-in-snake-valley/.

64. Sustainability used here refers to the ability of society to have mechanisms in place to prevent capital depletion.

65. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 3. The life cycle of water refers to all stages of the water supply process including pumping, movement, treatment, end use, and wastewater treatment. *Id.*

66. *See id.* at 10.

67. The energy intensity of water treatment is also variable depending on the quality of the source water. *Id.*

68. *Id.*

69. End-use water heating is the most energy intensive step of the water life cycle. Chandler et al., *supra* note 5, at 6. Up to 40 percent of all domestic water is heated before use. *Id.* at 6. A fifteen-minute shower can require up to 200 kWh of energy. *Id.* Technologies such as solar water heaters can considerably reduce a home's energy requirements. *See Estimating the Cost and Energy Efficiency of a Solar Water Heater*, U.S. DEP'T OF ENERGY (May 30, 2012), http://energy.gov/energysaver/articles/estimating-cost-and-energy-efficiency-solar-water-heater.

70. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 10.

treat water and wastewater; however, data for other aspects of the life cycle are limited or nonexistent.[71] Thirty percent of municipal energy costs are attributable to home water-heating, which costs an average household about $250 annually.[72]

Both water and wastewater treatment have large energy footprints.[73] In a drinking water treatment plant, large debris and contaminants are removed from the raw water, and then the water is run through a series of filtration processes.[74] The treated water is then pressurized and moved to customers through a network of pumps, pipes, tanks, and valves so that customers can have sufficient water at adequate pressure.[75] Beyond heating the water in the home, energy is required to filter and soften the water.[76] In addition to energy for household water use, the commercial and industrial sectors also have large energy requirements to produce hot water, steam, and air conditioning cooling water.[77]

The final stage in the water life cycle is wastewater treatment. In 2008, the United States provided some level of wastewater treatment service to 220 million people, or 74 percent of the population.[78] As in the original treatment process, solid materials are removed and other pollutants are filtered out before the water is discharged to the environment.[79] The level of energy required depends on the level of treatment. Thirty percent of wastewater treatment facilities provide the highest treatment available, "advanced treatment," which provides additional purification for the

71. *Id.* There are no comprehensive numbers measuring how much energy is used for customer end use, which can be the most energy intensive part of the life cycle. *Id.* Also, most studies only include power used and not other on-site fuels, such as natural gas, which is frequently used in water heating and at wastewater treatment plants. *Id.*

72. Chandler et al., *supra* note 5, at 1.

73. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 5–6.

74. *Id.* Water treatment is provided to 290 million Americans. *Id.* at 5. There is a growing movement for more stringent drinking water standards. *See* Robert S. Eshelman, *Utilities Brace for Clash Between Stricter Drinking Water Regs, CO2 Emissions Rules—Report*, E&E PUBLISHING (Sept. 12, 2012), http://www.eenews.net/public/climatewire/2012/09/12/2. Any of these, if promulgated, would likely add to the energy intensity required for treatment. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 15.

75. *Id.* at 6.

76. *Id.*

77. *Industrial Water Use*, U.S. GEOLOGICAL SURVEY, http://ga.water.usgs.gov/edu/wuin.html (last updated Oct. 31, 2012).

78. U.S. ENVT'L. PROT. AGENCY, EPA-832-R-10-002, CLEAN WATERSHED NEEDS SURVEY REPORT TO CONGRESS, at ix (2008).

79. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 7–8.

protection of ecosystems.[80]

Location—which determines the water source, distance to end-user, and infrastructure quality—is the most significant factor in determining the energy footprint of water extraction, use, and treatment.[81] The water source itself can have varying energy impacts. Surface water supplies, which often use gravity-fed systems, require less energy to extract than groundwater.[82] Deep unconfined or low-pressure confined aquifers necessitate more power to raise the water to the surface.[83] In addition, the quality of the source water determines the treatment level requirement to meet drinking water quality standards.[84] High-quality source water requires minimal treatment, which expends less energy.[85]

Pumping water can be energy intensive. If gravity-fed systems are possible, the energy footprint is much less than if the water is piped over mountains.[86] Also, distance from the source could have an impact.[87] Old infrastructure can also add an energy component that might not be present in new, more efficient systems.[88] Systems that have high leakage rates waste much of the energy required to get the water to the points of loss.[89]

Most regions of the United States have not effectively quantified how much energy is used to extract, move, and treat water for their communities, industries, and agriculture.[90] The

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80. *Id.* at 8.

81. *See, e.g.*, WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., *supra* note 12, at 15.

82. *Id.* at 11.

83. Pumping groundwater from a depth of 115 feet requires 540 KWh per million gallons, while pumping from almost 400 feet requires nearly 2,000 KWh per million gallons. *Id.* at 15.

84. STILLWELL ET AL., *supra* note 8, at 21.

85. *Id.*

86. *See, e.g.*, GARY KLEIN ET AL., CAL. ENERGY COMM'N, CALIFORNIA'S WATER-ENERGY RELATIONSHIP 10, 12 (2005), http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF. San Diego, located in southernmost California, gets a large percentage of its water from northern California. This water must be moved hundreds of miles and lifted over the Tehachapi Mountains. *Id.* The long haul pipeline networks of the State Water Project or the Colorado River Aqueduct supply more than 18 percent of California's urban and agricultural users. Jennifer R. Stokes & Arpad Horvath, *Energy and Air Emission Effects of Water Supply*, 43 ENVTL. SCI. & TECH. 2680, 2680 (2009).

87. STILLWELL ET AL., *supra* note 8, at 20.

88. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 12–13.

89. *Id.* at 13.

90. *But see* KLEIN ET AL., *supra* note 86, at 6–20.

state of California is an exception.[91] It uses a staggering 19 percent of its electricity and 32 percent of its natural gas to provide water.[92] While California may have uniquely intense energy requirements for water due to its geography, water creates large energy demands in most regions.

As water supplies become scarcer, new supply proposals often include treatment of non-potable water.[93] This can either take the form of desalinating brackish aquifers or seawater and is often coupled with long haul pipeline infrastructure to move the treated water considerable distances.[94] For perspective, if California met all its water needs with desalination, it would require 52 percent of the state's energy supply.[95] Cities are also increasing the use of treated wastewater effluent for potable and non-potable uses.[96] While these new supply technologies can reduce the need for new fresh water sources, the additional treatment required is also energy intensive. Therefore, a thorough tradeoffs analysis is important, but rarely completed.[97] The irony of many of these new or alternative water supply projects is that they actually increase water demand through the increased energy required.[98] In addition to power generation, there are other areas of the energy lifecycle

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91. *Id.*

92. *Id.* at 8.

93. *See, e.g.*, Colin McDonald, *SAWS Expects Rates Rising for Next 5 Years*, SAN ANTONIO EXPRESS-NEWS (Sept. 24, 2012), http://www.mysanantonio.com/news/environment/article/Demand-to-water-lawns-will-raise-water-bills-3891056.php.

94. *See* ASHLYNN S. STILLWELL ET AL., DESALINATION AND LONG-HAUL WATER TRANSFER 1–8 (2010). While desalination of brackish water requires less energy than seawater, it still requires two to three times the energy as compared to conventional water treatment processes for freshwater. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 15.

95. Stokes & Horvath, *supra* note 86, at 2680. Alternative technologies also have air emission impacts. Seawater desalination has an energy and air emissions profile that is 1.5 to 2.4 times larger than imported water; however desalinating brackish water is roughly half as intensive as desalinating seawater. *Id.*

96. Currently, approximately one billion gallons of wastewater are treated and used for non-potable uses, such as irrigation of public spaces and golf courses. CTR. FOR SUSTAINABLE SYS., UNIV. OF MICH., U.S. WASTEWATER TREATMENT FACTSHEETS 1 (2010), http://css.snre.umich.edu/css_doc/CSS04-14.pdf. This quantity is growing particularly in water scarce areas like the southwestern United States. *Id.*

97. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 15; *see also* Sandra Lowe Sanchez, *SAWS Desalination Program Gains Funding*, SAN ANTONIO BUS. J. (Dec. 21, 2010), http://www.bizjournals.com/sanantonio/news/2010/12/21/saws-desalination-program-gains-funding.html (noting the extensive price tag while not mentioning the energy needs).

98. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 15.

that require large quantities of water.

C. Other Collision Points

The traditional conversation regarding the energy-water nexus focused on water used for energy production and energy needed to move and treat water. However, diversification of the power grid and the push for cleaner technologies have broadened the topic. Examples of this can be found both before and after energy generation. First, the push for different energy sources has created a gas boom, resulting in the exponential growth of hydraulic fracturing, which requires immense amounts of water. Second, concerns about greenhouse gas emissions encouraged the development of post-combustion technologies that also increase a power plant's water footprint. Unfortunately, examining additional interrelated situations again highlights the lack of knowledge and understanding created by missing data and the need for coordination and regulation.

1. Hydraulic Fracturing

While the primary focus of this paper is not on fuel mining or extraction, the exponential increase in hydraulic fracturing (or "fracking") of shale formations for natural gas is included here because of its intensive water requirements. Fracking is the process of enhancing gas or oil production by injecting water and chemical additives at high pressure into tight formations that would not otherwise produce gas with normal drilling techniques.[99] The pressure is greater than the rock strength, so fractures in the rock are opened and enlarged by the fluid.[100] Once the fractures have been opened and extended, a propping agent is injected to keep the cracks open, and natural gas is produced.[101] While not a new process, hydraulic fracturing has increased exponentially with the development of new technologies and greater economic viability created by oil prices and domestic fuel needs.[102]

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99. MATTHEW E. MANTELL, DEEP SHALE NATURAL GAS: ABUNDANT, AFFORDABLE, AND SURPRISINGLY WATER EFFICIENT 3 (2009), http://www.energyindepth.org/wpcontent/uploads/2009/03/MMantell_GWPC_Water_Energy_Paper_Final.pdf.

100. *Id.*

101. *Id.*

102. *Id.* at 2–3.

All gas drilling has water requirements, but fracking can triple the water needed per well.[103] According to Chesapeake Energy, a typical fracking well requires an average of five million gallons.[104] The water needs are frontloaded in the well's lifecycle and occur early in the drilling process.[105] This can have advantages and disadvantages. If numerous wells are drilled in a short timeframe, a large amount of water will be unavailable for other users.[106] In a nonrenewing or slowly renewing water resource, this can have significant long-term consequences.[107] Areas that have sufficient water for existing and new users, coupled with sufficient recharge capabilities, may be able to absorb this spike in demand.

However, if a field is developed quickly, water demand will reduce drastically once initial development is completed.[108] Drilling in most areas is outpacing the collection of data that is necessary to predict impacts on water resources.[109] Overall volume of water used is determined by the number of wells developed, which cannot be known until a drilling permit is issued. The Barnett Shale in Texas, for example, expanded from 1,112 fracking well permits issued in 2004 to a total of 16,944 by the end of 2010.[110] In 2005 alone, 4,145 well permits were issued.[111]

Local characteristics determine the regional water and environmental impacts. Drilling companies frequently use available surface water, but groundwater is increasingly being

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103. *Id.*

104. *Id.* at 3. A typical deep shale gas well requires 65,000 to 600,000 gallons of water. CHESAPEAKE ENERGY CORP., WATER USE IN DEEP SHALE GAS EXPLORATION FACT SHEET 1 (2012), http://www.chk.com/media/educational-library/fact-sheets/corporate/water_use_fact_sheet.pdf.

105. CHARLES W. ABDALLA & JOY R. DROHAN, PENN ST. UNIV. COOP. EXTENSION MARCELLUS EDUC. TEAM, WATER WITHDRAWALS FOR DEVELOPMENT OF MARCELLUS SHALE GAS IN PENNSYLVANIA 3 (2009), http://pubs.cas.psu.edu/freepubs/pdfs/ua460.pdf. This assumes that the well is not fracked multiple times.

106. *See id.*

107. *Id.*

108. It is important to note that even a fast-growing field will see large numbers of wells drilled over the span of several years.

109. *See* HEATHER COOLEY & KRISTINA DONNELLY, PAC. INST., HYDRAULIC FRACTURING AND WATER RESOURCES: SEPARATING THE FRACK FROM THE FICTION 5 (2012), http://www.pacinst.org/reports/fracking/full_report.pdf.

110. R.R. COMM'N OF TEX., NEWARK, EAST (BARNETT SHALE) FIELD DISCOVERY DATE—10-15-1981 (2011), http://www.rrc.state.tx.us/data/fielddata/barnettshale.pdf.

111. *Id.*

utilized as well.[112] Shale formations, or "plays," experiencing significant gas development in the United States include the Barnett Shale in Texas, the Haynesville Shale in Texas and Louisiana, and the massive Marcellus, which spreads across Pennsylvania, Ohio, West Virginia, and New York.[113] Plays are also being developed in northern Colorado, Wyoming, Oklahoma, and Arkansas.[114]

Water used for drilling or fracking is consumptive.[115] In fact, unlike agricultural water uses, water removed from local sources and used for drilling or fracking will not return to the usable water cycle.[116] Once the water has been mixed with additives and run through the formation, the resulting water contains additional contaminants released from the shale formation.[117] This water is usually disposed of through on-site Class II injection wells or is trucked off site for disposal.[118] Some of the end-product water is treated and discharged into surface waters.[119]

Many drilling companies employ on-site water recycling and reuse technologies in an attempt to reduce total water usage and disposal quantities.[120] Produced water can be reused based on several factors, including quantity and quality.[121] Some formations, like the Barnett, have large amounts of naturally occurring water in the formation, resulting in a

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112. *See* Darrell T. Brownlow, *Eagle Ford Shale Play and the Carrizo Aquifer*, THE FOUNTAINHEAD, 4th Quarter 2010, at 1, 4 (describing the use of Texas' Carrizo Wilcox aquifer to hydraulically fracture the Eagle Ford Shale to recover oil and natural gas). Large municipal and agricultural interests currently rely on this aquifer for their water needs. *Id.*

113. MANTELL, *supra* note 99, at 3 fig.1.

114. *Id.*

115. A.W. GAUDLIP ET AL., SOC'Y PETROL. ENG'RS INT'L, MARCELLUS SHALE WATER MANAGEMENT CHALLENGES IN PENNSYLVANIA 5 (2008), http://s3.amazonaws.com/propublica/assets/monongahela/MarcellusShaleWaterManagementChallenges%2011.08.pdf.

116. *But see* MANTELL, *supra* note 99, at 9–10.

117. *See* ABDALLA & DROHAN, *supra* note 105, at 2.

118. GAUDLIP ET AL., *supra* note 115, at 5–6. Injection wells are regulated by the Underground Injection Control Program ("UICP") of the Federal Safe Drinking Water Act. *Id.* at 4. Class II wells are permitted for deep disposal of drilling byproducts in an effort to protect drinking water sources from contained contaminants. *Class II Wells—Oil and Gas Related Injection Wells (Class II)*, U.S. ENVTL. PROT. AGENCY, http://water.epa.gov/type/groundwater/uic/class2/ (last updated May 9, 2012).

119. These releases are regulated under the federal Clean Water Act through a discharge permit. GAUDLIP ET AL., *supra* note 115, at 2.

120. *See* MANTELL, *supra* note 99, at 8–9.

121. *Id.*

larger volume of produced water.[122] This can facilitate recycling if the water quality is not too poor.[123] Other formations are naturally drier and retain a larger portion of the produced water, reducing the need for recycling or disposal.[124]

Water treatment for flow-back water requires large amounts of energy; however, the energy requirements for treatment have not been quantified.[125] Energy needed would vary depending on the constituents in the return water. Water with higher dissolved solids content will require more energy to treat.[126] Much of this treatment is powered by gas product that is produced at the well site and not by off-site energy sources, but data should be collected for a full understanding of the energy-water relationship in this process.

Data are also lacking because regulation of water used for well development is often within the jurisdiction of a separate agency than the one charged with state water planning and permitting for other uses.[127] In Texas, groundwater used by the oil and gas industry is overseen by the Texas Railroad Commission.[128] In contrast, state water planning is actually the responsibility of the Texas Water Development Board, while surface water permitting is governed by the state environmental agency, the Texas Commission on Environmental Quality.[129] In addition, water used to produce oil and gas is often exempted from water regulations that apply to other uses.[130] This bifurcated regulatory oversight often provides insufficient data for water planning models, compromising water supply predictions particularly in areas of heavy fracking operation.[131] This lack of data adds an additional challenge to water planning where fracking is

122. *Id.* at 9.

123. *Id.*

124. *See generally id.*

125. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 12–13.

126. *Id.*

127. *See, e.g.*, JEAN-PHILIPPE NICOT & ERIC POTTER, HISTORICAL AND 2006–2025 ESTIMATION OF GROUND WATER USE FOR GAS PRODUCTION IN THE BARNETT SHALE, NORTH TEXAS 11 (2006).

128. *See generally* R.R. COMM'N OF TEX., http://www.rrc.state.tx.us/ (last visited Nov. 17, 2012).

129. *See generally id.*; TEX. WATER DEV. BD., http://www.twdb.state.tx.us/ (last visited Nov. 17, 2012).

130. *See, e.g.*, TEX. WATER CODE ANN. § 36.117 (West 2011) (prohibiting a groundwater district from denying a permit to drill and produce water for oil and gas production activities if the application meets all applicable rules as promulgated by the district).

131. NICOT & POTTER, *supra* note 127, at 11.

present.

Proponents of fracking argue that the water amount per unit of energy produced is smaller than other types of fuel.[132] Others point to the lucrative nature of drilling to defend its importance.[133] While both of these statements may be true in a vacuum, they provide little solace to a region whose water supply is depleted by gas development.[134] Drilling decisions need to be made based on regional characteristics. Local water supplies need to be studied in terms of availability and recharge capabilities before large-scale gas field development commences.

2. Post-Combustion Technologies

Increasing concern with unchecked air emissions, such as greenhouse gases and other air toxins, led to the creation of technologies to limit emissions.[135] Unfortunately, many of these technologies have environmental tradeoffs, including increased water consumption. Coal plants have more carbon dioxide emissions than other fuel plants and they provide about half of all the electricity generated in the United States.[136] Coal plants using the more technologically advanced supercritical or integrated gasification combined cycle (IGCC) have the advantage of fewer air emissions and reduced water needs compared to traditional pulverized coal (PC) combustion.[137] If new plants are built, these technologies should be used to maximize both air and water benefits.

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132. *See, e.g.*, MANTELL, *supra* note 99, at 6–7 (arguing that gas is the most water efficient raw fuel source, not including renewables such as wind and solar).

133. Brownlow, *supra* note 112, at 1–4 (calculating that a successful Eagle Ford well would bring a revenue of $520,000 per acre-foot of water to the mineral estate owner assuming at least $80 a barrel for oil and a 25 percent royalty payment).

134. *See* Joe Carroll, *Worst Drought in More Than a Century Strikes Texas Oil Boom*, BLOOMBERG, June 13, 2011, http://www.bloomberg.com/news/2011-06-13/worst-drought-in-more-than-a-century-threatens-texas-oil-natural-gas-boom.html. The current drought is impacting the Eagle Ford play in southeastern Texas by pitting users against one another and forcing oil and gas developers to buy water wherever they can find it to continue production. *Id.* Water usage in this already strained region is expected to increase ten times by 2020 and double again by 2050. *Id.* Many of these wells are just now having meters installed. *Id.*

135. *See Carbon Capture & Sequestration 101*, CTR. FOR AM. PROGRESS, (Mar. 6, 2009), http://www.americanprogress.org/wp-content/uploads/issues/2009/03/pdf/ccs_101.pdf.

136. SHUSTER & HOFFMANN, *supra* note 58, at 2.

137. GERDES & NICHOLS, *supra* note 4, at 6 fig.3-1.

Considerable water impacts are seen in postcombustion technologies such as carbon capture.[138] Carbon capture systems catch the waste stream before it is released into the environment and then inject the carbon dioxide and air toxics deep below the earth's surface for permanent storage.[139] While these technologies may help air quality, they greatly reduce plant efficiency and have additional scrubbing processes, which mean more water consumption.[140]

A pulverized coal plant with emissions capture must cool the fuel gas almost to ambient temperatures, which increases the cooling water necessary.[141] Some water can be regained through recovery when direct contact creates condensation of water vapor in the flue gas.[142] Additional water is also needed to wash the scrubbed gas from the absorber section before discharge from the stack.[143] Finally, there is a cooling requirement of the solvent regeneration process, which is not needed in a typical PC plant without carbon capture.[144] Similar issues occur with other combustion technologies; however, the amount of water use varies.[145]

A capture system in a PC plant using a recirculating cooling tower increases water consumption, as compared to a reservoir, per net power generation by 90 percent in a coal plant and 76 percent for a natural gas combined cycle plant.[146] IGCC has 50 percent more water consumption than PC plants because capture occurs before combustion.[147]

The increased water demanded by these technologies clearly supports the need for holistic planning policy to ensure there are not any unexpected water shortages. Other environmental impacts associated with power production, such as greenhouse gas emissions, must be considered. Without reductions in emissions, climate change is predicted to reduce snow pack and decrease precipitation in many areas.[148]

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138. *Id.*
139. *Id.*
140. *Id.* at 11, 13 fig.4-2.
141. SHUSTER & HOFFMANN, *supra* note 58, at 6.
142. *Id.*
143. *Id.*
144. *Id.*
145. *See id.* at 10.
146. GERDES & NICHOLS, *supra* note 4, at 13.
147. *Id.*
148. LENNY BERNSTEIN ET AL., INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 30 (Abdelkader Allali et al. eds., 2007) http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

However, as communities turn to emission control technologies in response to climate concerns, water must be a primary consideration. Otherwise, the solution to one problem will only exacerbate another problem. Intrinsic to understanding these potential impacts is having sufficient data measured and available. This is currently lacking.

D. Data Gaps

One of the biggest challenges in regulating the energy-water nexus is overcoming the dearth of information defining the extent of the relationship. Statistics and data points for many of the interactions previously discussed are inconsistent and scant.[149] Data for the power sector are collected by the United States Geologic Survey (USGS) and the U.S. Department of Energy's Energy Information Administration (EIA).[150] The USGS attempts to collect data every five years; unfortunately, the last consumption values were reported in 1995.[151] Some state agencies also collect data, but they do not always use standardized units or formats, making cross-comparison difficult.[152] EIA data is collected more frequently; however, the exemption of nuclear and some gas plant data does not give the full picture of water use.[153] Newer technologies, such as biomass and geothermal systems, also have limited data available regarding their water use.

There are also significant data gaps associated with energy needs for the water life cycle.[154] Many treatment plants do not have metering systems to show how much power is used to treat water.[155] Studies that do exist use estimates that are

149. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 10.

150. MACKNICK ET AL., *supra* note 38, at 5.

151. *Water Use in the United States*, U.S. GEOLOGICAL SURVEY, http://water.usgs.gov/watuse/ (last updated Sep. 20, 2012).

152. *Id.* An additional issue with data collection is that some states require limited reporting if the withdrawals are from a company-owned cooling pond, unless additional state water is needed to replenish supplies. *See, e.g.*, TEX. WATER CODE ANN. § 11.021 (West 2007) (excluding private ponds or reservoirs from the definition of state water and therefore outside of state permitting jurisdiction). This means that the water consumption reported does not provide a full picture. Water lost through evaporation at these reservoirs is also not a required value. STILLWELL ET AL., *supra* note 8, at 8.

153. MACKNICK ET AL., *supra* note 38, at 5; U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-23, IMPROVEMENTS TO FEDERAL WATER USE DATA WOULD INCREASE UNDERSTANDING OF TRENDS IN POWER PLANT WATER USE 48 (2009).

154. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 10.

155. *Id.* at 10; *see also supra* note 65 and accompanying text.

criticized for not reflecting the newer, more energy intensive treatment technologies.[156] Similarly, the transmission infrastructure that moves water is also not measured.

Within the home, power used to heat water is not differentiated from power used for other purposes. Water heating is often the most energy intensive stage of the life cycle.[157] Its omission means that power estimates for the water life cycle will be considerably underreported. It also makes it difficult for utilities to target conservation programs based on predicted savings yield. Existing studies also deal primarily with electricity and not the natural gas used to heat water, which should be included. Equivalent gaps exist for commercial and industrial uses. Without the ability to quantify the relationship between these two sectors, it is impossible to accurately manage and plan for sustainable use. Although there are few policies that manage the energy and water sectors together, some regulations promulgated specifically for one sector have positive impacts on the other.

II. EXISTING APPLICABLE REGULATIONS

Although considerable amounts of data, education, and policy are still needed, some progress is being made, even if unknowingly. Programs that target one sector can positively affect the other as a co-benefit. Combined energy and water initiatives start the conversation even if they are not successfully promulgated. These can also serve as models for future policy.

This Part discusses current ideas that can be expanded or used as models for regulating the water-energy nexus. These ideas include conservation and efficiency measures in either water or power. As discussed, reductions in one arena positively impact the other. Similarly, while no regulations have been passed limiting power plant technologies just for water usage concerns, limitations focused on water quality and ecological concerns can serve as models. Finally, energy-water specific legislation is not a totally new concept, and some unsuccessful bills can be used as starting points for future policy.

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156. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 10.
157. STILLWELL ET AL., *supra* note 8, at 23.

A. *Conservation and Efficiency*

Perhaps the most obvious starting point in managing the energy-water relationship is to use less of both. Because of their intertwined relationship, saving one also saves the other. In addition to relieving demand, conservation and efficiency can reduce harmful air emissions from power plants, reduce impacts on water ecology, and save customers' money.[158] Many states and the federal government have taken action to encourage either water or energy efficiency, but such initiatives rarely contemplate both sectors combined.

Two efficiency programs run by the U.S. Environmental Protection Agency (EPA) are Water Sense and Energy Star.[159] Each program identifies products that save water or energy, respectively, and encourages their purchase through recommendations and financial incentives.[160] Water Sense has the additional stated goals of decreasing household (indoor and outdoor) use of water and encouraging water savings in the commercial and industrial sectors.[161]

The Water Sense website has educational information about ways to save water and an extensive list of financial incentive programs offered for retrofits throughout the U.S. so people know what is available in their community.[162] The program's website boasts that it has helped consumers save a cumulative 125 billion gallons of water and $2 billion in bills since its 2006 inception.[163] Interestingly, saving energy is also listed as a water-saving strategy, and a link to a fact page includes an explanation of the energy-water relationship.[164] However, energy is not listed on any of the introductory webpages. Most telling of the lack of recognition of joint

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158. Chandler et al., *supra* note 5, at 1.

159. *See WaterSense: An EPA Partnership Program*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/WaterSense/ (last updated Nov. 15, 2012); *About ENERGY STAR*, ENERGY STAR, http://www.energystar.gov/index.cfm?c=about.ab_index (last visited Nov. 17, 2012).

160. *See WaterSense: An EPA Partnership Program*, *supra* note 159; *About ENERGY STAR*, *supra* note 159.

161. *WaterSense: About Us*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/WaterSense/about_us/index.html (last updated Nov. 15, 2012).

162. *WaterSense: Rebate Finder*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/WaterSense/rebate_finder_saving_money_water.html (last visited Oct. 29, 2012).

163. *WaterSense: About Us*, *supra* note 161.

164. *See WaterSense: An EPA Partnership Program*, *supra* note 159; *About ENERGY STAR*, *supra* note 159.

impacts is the clear bifurcation of the Water Sense program from the EPA's Energy Star program.[165]

Energy Star is an EPA program administered in partnership with U.S. Department of Energy (DOE).[166] This program is the energy equivalent of Water Sense. The "Energy Star" designation is given to energy efficient appliances, the purchase of which is often incentivized by federal and state government programs by providing rebates to consumers.[167] The program also focuses on educating consumers about saving energy.[168] Unlike the Water Sense website, the Energy Star website contains no reference to water or water savings.[169]

In addition to these federal programs, many utilities and cities across the nation have conservation and efficiency programs in one or more sectors independently or in partnership with the federal programs.[170] Some of the programs are extremely diverse and successful. And some include a suite of educational, incentive-based, and regulatory initiatives.[171] Others only recommend reduced usage without any real program to ensure results.[172] This is particularly disappointing in areas where water is already at a premium.[173]

Perhaps the best-known voluntary building code program is the Leadership in Energy and Environmental Design

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165. Through use of their labeled products, the program has saved 38.4 billion kWh of electricity, equaling thirteen million metric tons of carbon dioxide. *WaterSense: Milestones*, U.S. ENVTL PROT. AGENCY, http://www.epa.gov/WaterSense/about_us/milestones.html (last updated Nov. 15, 2012).

166. *About ENERGY STAR*, *supra* note 159.

167. *See, e.g.*, *Energy Efficient Appliance Rebate Program*, STATE ENERGY CONSERV. OFFICE, http://seco.cpa.state.tx.us/arra/rebate/index.php (last visited Nov. 17, 2012).

168. *About ENERGY STAR*, *supra* note 159.

169. *Id.*

170. *See* Tracy Idell Hamilton, *CPS' Energy Efficiency Program Is Saving Power Usage and Money*, SAN ANTONIO EXPRESS-NEWS (Apr. 27, 2010), http://www.mysanantonio.com/news/environment/article/CPS-energy-efficiency-program-is-saving-power-787454.php.

171. *See, e.g.*, *Rebates and Incentives*, AUSTIN ENERGY, http://www.austinenergy.com/Energy%20Efficiency/Programs/Rebates/index.htm (last visited Oct. 31, 2012).

172. *See, e.g.*, News Release, Judi Pierce, Pub. Info. Officer, Brazos River Auth., Brazos River Authority Recommends Voluntary Water Conservation Efforts for Lake Aquilla (Sept. 13, 2006), http://www.brazos.org/newsPdf/Aquilla_Stage2Release1.pdf.

173. *See, e.g.*, Jessica Savage, *Corpus Christi Residents Use More Water During Drought*, CORPUS CHRISTI CALLER-TIMES (Feb. 12, 2012), http://www.caller.com/news/2012/feb/12/corpus-christi-residents-use-more-water-during/ (explaining that city officials were not moved to pass stricter watering rules despite record water use during extreme drought).

(LEED) designation sponsored by the U.S. Green Building Council.[174] LEED is a voluntary program that provides building owners and operators with a framework for implementing practical and measurable green building design, construction, operations, and maintenance solutions through a checklist of options.[175] Building options such as site location, use of sustainable building materials, water and energy efficiency, and indoor ambient air quality each accrue points toward LEED certification.[176] A project can choose to maximize efficiencies on any of the listed criteria and, depending on the total number of points accumulated, the building can receive a LEED award rating.[177] While LEED is an effective program in encouraging smart building choices, its voluntary nature can limit its market saturation.

In addition to education and voluntary or incentive-based programs, regulatory requirements—particularly in plumbing and building codes—can save large quantities of energy and water. Building codes may require new and existing buildings to be constructed or retrofitted to meet a minimum set of efficiency requirements.[178] These can be promulgated at the federal, state, municipal, or utility level.[179] To achieve true market transformation, regulations as well as incentive programs should be managed at all levels of government.

Energy and water usage is as intertwined within buildings as it is in other sectors of the community.[180] Energy used to heat water in the home can constitute 15 to 30 percent of a family's electric bill, and large quantities of water are wasted

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174. BLDG. DESIGN & CONSTR., GREEN BUILDING AND WATER PERFORMANCE 18 (2009), *available at* http://www.bdcnetwork.com/2009-white-paper-green-buildings-water-performance.

175. *LEED*, U.S. GREEN BLDG. COUNCIL, https://new.usgbc.org/leed (last visited Nov. 30, 2012).

176. LEED was initially criticized for not sufficiently including water usage in its evaluation of buildings seeking certification. *See* Winston Huff, *Water Efficiency Changes for LEED 2012*, PLUMBING ENG'R (June 2012), http://plumbingengineer.com/june_12/green.php. In 2009, the program added a requirement to reduce water use by 20 percent. BLDG. DESIGN & CONSTR., *supra* note 174, at 18.

177. *Id.*

178. U.S. ENVTL. PROT. AGENCY, BUILDING CODES FOR ENERGY EFFICIENCY 1, http://www.epa.gov/cleanenergy/documents/suca/buildingcodesfactsheet.pdf.

179. *Id.* at 3–4. The first mandated low-flow toilets occurred in the Federal Energy Policy Act of 1992, which banned any toilets consuming more than 1.6 gallons per flush. BLDG. DESIGN & CONSTR., *supra* note 174, at 18. In 2009, Los Angeles became the first city to mandate high efficiency fixtures in new construction and renovations. *Id.*

180. *Id.* at 38.

waiting for the hot water to arrive.[181] Plumbing fixtures that speed the process of heating while reducing the amount of flow save considerable amounts of water and energy.[182] Other water saving fixtures that can be required through codes include low-flow toilets, waterless urinals, low-flow showerheads, water-efficient clothing washers and dishwashers, and pre-rinse spray valves in commercial kitchens.[183] Each of these advancements can be required for new builds as well as retrofits. Rebate and incentive programs can speed market transformation.[184]

Commercial buildings have additional water saving opportunities beyond conservation-oriented fixtures. Large efficiency opportunities exist within those buildings' mechanical systems, such as electric chillers and other heating, ventilation, and air conditioning (HVAC) equipment.[185] This equipment constitutes a large percentage of a building's total electricity use, so small changes can result in big savings.[186] Proper building design can also reduce the need for HVAC units.[187]

Implementation of these changes on a wide scale can have substantial impact. Some studies estimate that "widespread use of green building technology could total [a savings of] 25 billion gallons [of water] by 2015."[188] The DOE estimates that 78 billion gallons could be saved by 2025 through the use of green construction.[189] Each of those saved gallons also has a corresponding power savings and an additional related water savings at the power plant.[190]

Similarly, all fixtures that save energy, such as compact fluorescent light bulbs, save water at the power plant because less power generation is required.[191] Of course, energy

181. *Id.* at 40.

182. *Id.*

183. *Id.* at 19 tbl.3.1. Eighty percent of existing urinals use five times as much water as the federal standard of one gallon per flush. *Id.* at 18. Retrofitting these would save more than 150 billion gallons of fresh water per year. *Id.*

184. *See, e.g.*, Calvin Finch, *Efficient Appliances*, PLANT ANSWERS, http://www.plantanswers.com/calvin/030301_Efficient_Appliances.htm (last visited Nov. 17, 2012) (chronicling the efficacy of the toilet rebate program).

185. BLDG. DESIGN & CONSTR., *supra* note 174, at 42.

186. *Id.*

187. *Id.*

188. *Id.* at 39.

189. *Id.*

190. *See supra* section II.A–B.

191. BLDG. DESIGN & CONSTR., *supra* note 174, at 40.

efficiency extends well beyond light bulbs. Traditional energy efficiency, such as encouraging compact florescent light bulbs, "focuses on reducing direct energy consumption in the use phase of a product, whereas nontraditional energy efficiency considers reducing energy consumed over the whole life cycle of a product."[192] The life cycle analysis would include energy footprint for production, but also incorporate water and energy required during use. Understanding this "embedded energy" is critical to making wiser choices.[193]

As electric generation sufficiency becomes a growing concern, building code initiatives increase in importance because they can alleviate the need for new power.[194] Avoided generation is considerably less expensive than new generation and associated infrastructure.[195] These cost savings can increase exponentially if water savings are also included in the calculation.

Many building codes focus on a few specific sectors including lighting, HVAC, and water heating.[196] Requirements for an efficient building "envelope"—the physical separator between the interior and the exterior environments—are also common.[197] These requirements focus on everything from building materials to window types, roofing, and foundation—all of which can make significant energy demand differences

192. Steven Weissman & Lindsay Miller, *The California Public Utilities Commission's Pilot Program to Explore the Nexus of Energy Efficiency and Water Conservation*, 22 PAC. MCGEORGE GLOBAL BUS. & DEV. L.J. 257, 269 (2010).

193. *Id.* at 270.

194. "Energy consumption in buildings accounts for one-third of all the energy used in the United States and two-thirds of the total electricity demand." U.S. ENVTL. PROT. AGENCY, *supra* note 178, at 1. Texas projected that adoption of the International Energy Conservation Code (IECC) in 2001 would result in a savings of 1.8 billion kilowatt-hours over a twenty-year horizon. *Id.* at 2.

195. Bill Opalka, *Pioneering Energy Efficiency: Moving Ahead with Less Government Help*, ENERGYBIZ, May/June 2012, http://www.energybiz.com/magazine/article/265689/pioneering-energy-efficiency?quicktabs_4=2. Both San Antonio's CPS Energy and Austin's Austin Energy have successfully saved enough power through energy efficiency programs to avoid building a new power plant, resulting in a tremendous cost savings. *Id.*; Karen Underwood, *City of Austin Mandates Home Energy Audits to Avoid Building New Power Plant*, TREEHUGGER (June 8, 2009), http://www.treehugger.com/corporate-responsibility/city-of-austin-mandates-home-energy-audits-to-avoid-building-new-power-plant.html.

196. *See, e.g.*, PAC. NW. NAT'L LAB., IMPACTS OF THE 2009 IECC FOR RESIDENTIAL BUILDINGS AT STATE LEVEL 3 (U.S. Dep't of Energy Bldg. Energy Codes Prog., Sept. 2009), http://energycodesocean.org/sites/default/files/resources/IECC2009_Residential_Nationwide_Analysis.pdf.

197. *Id.*

within the residential sector.[198] Commercial and industrial efficiency options are much broader and often include optimization of on-site opportunities such as capturing and reusing waste heat.[199]

This list of conservation and efficiency measures is not meant to be exhaustive. Energy efficiency targets and the promotion of renewable resources by federal energy bills, state efficiency bills, and local building codes all contribute to protecting resources, but they will not be enough to bridge the gap between the energy and water sectors. A broader, more direct approach is necessary. In addition to regulating at the end use level, the power plant itself can, and should, be regulated in a way that saves water.

B. *Regulating Power Plant Technology*

Similar to efficiency building codes or conservation plumbing specifications, the EPA and some states are attempting to limit the types of cooling technologies that can be used in power plants. In March 2010, the New York State Department of Environmental Conservation released a draft policy establishing closed-loop cooling as the industry performance goal.[200] The motivations for the policy were to minimize the impact power plant cooling water intake structures have on aquatic life by prescribing reductions in impingement mortality and entrainment, and to reduce overall water withdrawals as plants move to closed-loop cooling.[201] Although the impetus for these policies was ecological, the model can be used to pass similar regulations aimed at saving water.

In April 2011, the EPA proposed similar regulations under section 316(b) of the Clean Water Act for existing facilities that use cooling water intake structures to withdraw water from

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198. U.S. ENVTL. PROT. AGENCY, *supra* note 178, at 1.; *e.g.*, PAC. NW. NAT'L LAB., *supra* note 196, at 3–4.

199. U.S. DEP'T OF ENERGY, UNLOCK ENERGY SAVINGS WITH WASTE HEAT RECOVERY 1 (July 2012), http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/wasteheatrecovery_factsheet.pdf.

200. Jeff Beattie, *New York Proposes Costly Retooling of Power Plant Cooling*, COAL POWER (Apr. 1, 2010), http://www.coalpowermag.com/plant_design/New-York-Proposes-Costly-Retooling-of-Power-Plant-Cooling_258.html.

201. *See* MACKNICK ET AL., *supra* note 38, at 6 (stating that "[o]nce-through cooling technologies withdraw 10 to 100 times more water per unit of electric generation than" closed-loop cooling technologies).

"waters of the U.S." and require a National Pollutant Discharge Elimination System (NPDES) permit.[202] Section 316(b) of the Clean Water Act requires the best technology available for the location, design, construction, and capacity of cooling water intake structures to minimize adverse environmental impacts.[203] The primary purpose of the proposed change is to "reduce injury and death of fish and other aquatic life caused by cooling water intake structures existing at power plants and factories."[204] These regulations would be applicable to 670 existing power plants, which currently withdraw over 214 billion gallons of water per day.[205]

The EPA's proposed regulations would consist of three components. First, facilities withdrawing at least 25 percent of their water from an adjacent water body for cooling equaling more than two million gallons per day (MGD) would be subject to a limit on the number of fish deaths associated with its intake structures.[206] The facility can determine the best technology to meet the limit.[207] The facility also has the option of reducing the rate of withdrawal to 0.5 feet per second.[208] Second, facilities withdrawing more than 125 MGD would be required to develop studies with public input regarding what technologies are best to limit fish kills.[209] Third, facilities that upgrade and add electrical generation capacity must use closed-loop or equivalent cooling technology.[210] The comment period for the proposed regulations has closed, but the final regulations have not yet been promulgated.

California has also realized the environmental impacts of open-loop cooling and has made several efforts to move away from this technology.[211] In 2006, the California State Lands

202. National Pollutant Discharge Elimination System, 76 Fed. Reg. 22174 (proposed Apr. 20, 2011) (to be codified at 40 C.F.R. pts.122, 125). This rule was proposed as a result of a consent decree with environmental groups. U.S. ENVTL. PROT. AGENCY, 820-F-11-002, PROPOSED REGULATIONS TO ESTABLISH REQUIREMENTS FOR COOLING WATER INTAKE STRUCTURES AT EXISTING FACILITIES 1 (Mar. 2011), http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/upload/factsheet_proposed.pdf; *see also* Entergy Corp. v. Riverkeeper, Inc., 556 U.S. 208, 208 (2009).

203. 33 U.S.C. § 1326(b) (2006).

204. U.S. ENVTL. PROT. AGENCY, *supra* note 202, at 1–2.

205. *Id.*; *Entergy Corp*, 556 U.S. at 215.

206. National Pollutant Discharge Elimination System, 76 Fed. Reg. at 22174.

207. *Id.*

208. *Id.*

209. *Id.*

210. *Id.*

211. In 2002, the California Energy Commission had ordered a study

Commission unanimously passed a resolution regarding once-through cooling in state power plants.[212] The resolution recognized that California had twenty-one coastal power plants utilizing once-through cooling and located in areas with sensitive fish populations.[213] It stated that studies had documented the harm to the fish population caused by the power plants due to ingestion through plant intakes.[214] The Commission resolved that the state's Energy Commission and Water Resources Control Board should promulgate policies that would eliminate these negative impacts for new and existing power plants.[215] The resolution proposed halting approval of plants using once-through cooling and suggested that other agencies should also not permit plants with this cooling technology.[216]

In May 2010, the California State Water Resources Control Board followed suit.[217] Like the subsequently proposed EPA regulations, the Control Board's resolution established a uniform technology-based standard to implement section 316(b) of the Clean Water Act using NPDES permits.[218] It applied to nineteen power plants along the California coast, which were required to submit an implementation plan demonstrating the design, construction, or operational measures that they would use to comply.[219] To comply, plants could either reduce the flow of water into their pipes by 93 percent or reduce total mortality by 93 percent.[220] By failing to mandate a technology, the policy gave the facility the ability to decide how to comply.[221] A

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comparing the environmental impacts of alternate cooling technologies considering many factors including water use. CAL. ENERGY COMM'N, COMPARISON OF ALTERNATE COOLING TECHNOLOGIES FOR CALIFORNIA POWER PLANTS ECONOMIC, ENVIRONMENTAL AND OTHER TRADEOFFS 8-2 to -3 (2002), http://www.energy.ca.gov/reports/2002-07-09_500-02-079F.PDF.

212. CAL. STATE LANDS COMM'N, RESOLUTION BY THE CALIFORNIA STATE LANDS COMMISSION REGARDING ONCE-THROUGH COOLING IN CALIFORNIA POWER PLANTS 1–3 (2006).

213. *Id.* at 1.

214. *Id.*

215. *Id.* at 3.

216. *Id.*

217. CAL. STATE WATER RES. CONTROL BD., RES. No. 2010-0020, (2010).

218. *Id.* at ¶ 2.

219. *Id.* at ¶ 1.

220. *See California Water Board Changes Power Plant Regulations to Protect Aquatic Life*, CIRCLE OF BLUE (May 6, 2010), http://www.circleofblue.org/waternews/2010/world/north-america/california-water-board-changes-power-plant-regulations-to-protect-aquatic-life/.

221. Based on the Supreme Court's 2009 decision in *Entergy Corp. v. Riverkeeper, Inc.*, cost is a valid criterion in the selection of a cooling technology as

Statewide Advisory Committee on Cooling Water Intake Structures was also created and given the task of advising the State Water Board on the implementation of policies that would protect aquatic life while still maintaining grid security.[222] Although these policies primarily target species protection, they will likely have water withdrawal impacts and can be used as a model for policies designed specifically to reduce water use.[223] In addition to policies that affect the energy-water nexus indirectly, there have been regulatory attempts to join the sectors.

C. *Direct Regulation*

There are many ways to directly regulate the energy-water nexus, both on a federal and state level. However, few efforts have been made to do so, and those that have been put forth have not passed.

In 2009, U.S. Representative Bart Gordon of Tennessee introduced H.R. 3598, titled the Energy and Water Research Integration Act, aimed at considering the "water intensity in the Department of Energy's energy research, development, and demonstration programs to help guarantee efficient, reliable, and sustainable delivery of energy and water resources."[224] Under this bill, DOE would have to seek energy-efficient technologies to minimize freshwater use and increase water use efficiency as well as use nontraditional water sources.[225] Importantly, the bill required interagency collaboration between DOE and other federal agencies with relevant programs.[226] It also called for the creation of the Energy-Water Architecture Council to "promote and enable improved energy and water resource data collection reporting and technological innovation."[227] The council would have had a representative from each agency (federal and nonfederal) involved in research in energy and water resource data.[228] The bill authorized the

mandated by EPA rules, but the Court did not extend that obligation to state regulations. 556 U.S. 208, 226 (2009).

222. CAL. STATE WATER RES. CONTROL BD., *supra* note 217, ¶ 19.

223. *See* MACKNICK ET AL., *supra* note 38, at 15.

224. Energy and Water Research Integration Act, H.R. 3598, 111th Cong. (2009).

225. *Id.*

226. *Id.*

227. *Id.*

228. *Id.*

appropriation of $325 million over the period between 2011 and 2015, which would have cost less than one dollar per American.[229] The U.S. House of Representatives passed H.R. 3598, but the bill never reached a vote in the U.S. Senate.[230]

A newly proposed bill by New Mexico Senator Jeff Bingaman, familiarly named the Energy and Water Integration Act of 2011, has many of the same provisions of the 2009 Gordon bill with some valuable expansions.[231] It calls for water and energy efficiency studies, research priorities and enhanced assessments on water-related energy consumption, a research and development roadmap, a grant program for energy-water clean technology, and a study of savings in both sectors.[232] Unlike the Gordon bill, which called for the DOE to join with other federal agencies, the Bingaman bill actually names the entities that must participate, including the EPA, the National Academy of Sciences, and the Secretary of the Interior.[233] This mix of policymakers and academics is appropriate considering the lack of data available.

As seen in the Gordon bill, the Bingaman bill requires a life cycle assessment of water usage for electricity productions in relation to quantity of energy produced.[234] Life cycle is defined as exploration, extraction or growing, processing, transportation, and production of electricity for a long list of fuels including coal, natural gas, solar, and biomass.[235] The bill also goes beyond the power sector and includes transportation, calling for an analysis of the life cycle water withdrawn and consumed in transportation fuels such as oil sands, electric vehicles, and corn ethanol.[236]

On the water supply side, the Bingaman bill requires the measurement of energy for water supply projects and orders the review of Bureau of Reclamation projects for water and energy conservation best practices.[237] Desalination research for brackish groundwater is also required.[238] Interestingly, this

229. *Id.*
230. *Id.*
231. *See* Energy and Water Integration Act of 2011, S. 1343, 112th Cong. (2011).
232. *Id.*
233. *Id.*
234. *Id.*
235. *Id.*
236. *Id.*
237. *Id.*
238. *Id.*

section of the bill does not mention the obligation to quantify the energy footprint of these systems. The bill is currently reported by committee and many changes to the bill may occur, but it is a good example of what can be done at the federal level.

In 2009, Texas State Representative David Farabee submitted H.B. 4206, which proposed mandating that anyone seeking an air permit complete a water availability study.[239] This study would have required a showing that a sufficient amount of water was available for the lifetime of the plant,[240] for both the plant and existing users.[241] The information would have been made available to the public and submitted to the regional planning group at the time of the air permit application, with issuance of the air permit contingent on its completion.[242] This timing is important because the surrounding community often does not discover water issues until a project is already permitted or actually being built.[243] The bill highlighted the fact that many power providers do not consider water issues at the time of plant proposal and siting.[244] While the bill received a hearing in committee, it was never voted out for a floor vote before the legislative session concluded.[245]

Although some current policies exist that do affect energy and water, much more needs to be done to alleviate current and future choke points. There are policy alternatives at all levels of government and a suite of measures is recommended to avoid a future supply crisis.

III. REGULATING THE NEXUS

The importance of maximizing the efficiency of both the water and power sectors is obvious in many ways. Communities need to ensure that limited resources can continue to serve a burgeoning population. Another major issue

239. *See* H.B. 4206, 81st Leg., Reg. Sess. (Tex. 2009).
240. *Id.*
241. *See id.*
242. *Id.*
243. *See id.* (requiring the release of water data at the time of the air permit application).
244. *See id.*
245. *See 81(R) History for HB 4206*, TEX. LEG. ONLINE, http://www.capitol.state.tx.us/BillLookup/History.aspx?LegSess=81R&Bill=HB4206 (last visited Nov. 30, 2012).

that is rarely discussed in the context of water is energy security.[246] The energy sector is equally vulnerable to water shortages as it is to any other threat; however, limited policy is in place to protect the grid against drought.[247]

In order for our society to function fluidly, industry and communities must have a steady source of energy and water. When either energy or water becomes unreliable, it can negatively impact an area's growth potential.[248] The ability of cities and industry to be resilient is particularly critical now as climate change creates more extreme and less predictable weather patterns.[249] Cities must ensure resource consistency and reliability during times of drought, not just under average weather conditions. Some solutions need to be promulgated at the federal level; however some are more appropriate at the state or regional level. First and foremost, more information about the energy-water relationship is needed.

A. *Filling the Data Gap*

The starting place for any regulations or policies to manage the energy-water nexus is filling the data gaps.

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246. *See* Ashlynn S. Stillwell et al., *Technical Analysis of a River Basin-Based Model of Advanced Power Plant Cooling Technologies for Mitigating Water Management Challenges*, 6 ENVTL. RES. LETTERS 2 (2011).

247. *Compare* MACKNICK ET AL., *supra* note 38, at 1 (highlighting that the energy sector is vulnerable to changes in the availability of water resources), *with* Hannah Northey, *Lawmakers Taking on Cyber Attacks, Nuclear Threats*, N.Y. TIMES, June 1, 2011, http://www.nytimes.com/gwire/2011/06/01/01greenwirelawmakers-taking-on-cyber-attacks-nuclear-thre-26292.html (describing legislative efforts to protect the energy grid from a terrorist threat).

248. *See, e.g.*, *Toyota's Decision a Boost for S.A.*, SAN ANTONIO EXPRESS-NEWS (Aug. 28, 2009), http://www.mysanantonio.com/default/article/Toyota-s-decision-a-boost-for-S-A-840397.php. Due to its limited supply in San Antonio, Texas, water was a major issue for Toyota in deciding whether to locate their new plant there. *See* Melissa Martinez, *San Antonio Water Rights and Usage*, ABOUT.COM, http://sanantonio.about.com/od/historyandlandmarks/a/waterrights.htm (last visited Nov. 30, 2012). The city was able to demonstrate that industry had never been asked to reduce production even during times of water rationing. *Dos Rios Celebrates 20 Years of Turning Sewage into Economic Gold*, SAN ANTONIO WATER SYS. (Oct. 26, 2007), http://www.saws.org/latest_news/NewsDrill.cfm?news_id=469. For its part, Toyota designed the new plant to minimize energy and water usage. *See* Vicki Vaughan, *Toyota Wins Award from EPA*, MY.SA.COM BLOG (Apr. 12, 2011), http://blog.mysanantonio.com/clockingin/2011/04/toyota-wins-award-from-epa/. This type of partnership is essential if communities want to expand and remain sustainable. In Atlanta, a water conflict was narrowly avoided between the thermoelectric and other water intensive industrial users such as Georgia-Pacific Corporation and Pepsi. Sovacool, *supra* note 60, at 25–26.

249. *See* WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., *supra* note 12, at 11.

Without a proper understanding of the current situation, there is no way to plan effectively or measure progress. As resources become further limited, decisions will need to be made based on a thorough analysis of the tradeoffs created by each energy or water technology; such decisions cannot be accurate without sufficient data. Data collection needs to be continuous and consistently formatted so that accurate comparisons can be made between sectors and regions.[250] Federal and state agencies should standardize measures, as well as increase and coordinate reporting requirements in both the energy and water sectors.[251]

Additional data would give decision-makers the ability to make determinations in one sector based on impacts on other sectors, leading to more holistic planning.[252] Better knowledge of water demands over the life of a plant can be used to locate new generation facilities in areas where water resources are not threatened or, in the alternative, it can guide the decision towards a cooling technology that is suitable for the region.[253] Conversely, understanding the energy footprint of water supply technologies and resources can influence water allocation development by providing the true cost that will be passed to consumers.

In the energy sector, power plants must start reporting all water withdrawn, including permitted water, privately owned reservoir water, and consumed water. Cooling pond water lost through evaporation must be measured or estimated and reported. Data reporting needs to be more frequent than current practices. The latest USGS report on water withdrawal data was published in 2005 and the agency website states that the next report release is not expected until 2014.[254] USGS has also discontinued data collections from a considerable number

250. *See* MACKNICK ET AL., *supra* note 38, at 5.

251. *Id.* at 33–37 tbl.4; *see also* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 153, at 16–17. State water law can dictate data collection, which reinforces the need for federal data collection and dissemination.

252. *See generally* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 153.

253. *See id.* at 21–23. *But see id.* at 33–41 (noting that states are currently inconsistent in the way they consider the impacts that proposed power plants will have on water).

254. *Water Use in the United States*, U.S. GEOLOGICAL SURVEY, http://water.usgs.gov/watuse/ (last updated Sept. 20, 2012); *see also* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 153, at 33–41 (explaining state dependence on federal data). Due to budget cuts, USGS is no longer distributing water consumption data for thermoelectric power plants or other water users. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 153, at 49.

of streamflow gauges, further reducing data availability.[255] In an ever-changing world, this information gap can lead to ineffective planning and threaten resource sustainability.

To truly be effective, agencies must collect data regarding water withdrawn and consumed from all modes of generation and advanced technologies.[256] Newer generation technologies, such as biomass and geothermal, should provide water usage data so they can be reasonably compared with traditional generation. Water-use data needs to include the water source, particularly if it is dependent on an alternative water supply, such as water reuse.[257] Although states have flexibility on how they choose to use federally and locally collected water data, additional, clear information may encourage states with limited review resources to increase the stringency with which water impacts are included in the power plant approval process.

Additional data is also needed to properly ascertain the impacts of hydraulic fracturing on water resources.[258] Unfortunately, drilling is outpacing the understanding of baseline conditions of the water resources that will be affected. As a result, decisions about drilling are often made without fully understanding their long-term consequences.[259] While surface water is likely to be the first source option because of the ease of access, in areas where this is not available, groundwater mining is increasing.[260] The quantity of water used for a fracking job is often unreported because of state law

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255. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 153, at 43–44 fig.8.

256. *See supra* text accompanying note 119; U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 153, at 46–48, 51.

257. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 153, at 47–48, 51.

258. *See supra* Part II.D.1; U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-11-35, A BETTER AND COORDINATED UNDERSTANDING OF WATER RESOURCES COULD HELP MITIGATE THE IMPACTS OF POTENTIAL OIL SHALE DEVELOPMENT 9–10 (2010). Any water used for production must be added to the water also needed for combustion later in the life cycle. *Id.* at 16.

259. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 258, at 42–43.

260. *Id. at* 27; *e.g.*, Brownlow, *supra* note 112, at 1–4. "[I]n the Upper Trinity Groundwater Conservation District ("UTGCD") west of Fort Worth, the share of groundwater used by frackers was 40 percent in the first half of 2011, up from 25 percent in 2010." Josh Harkinson, *As Texas Withers, Gas Industry Guzzles*, MOTHER JONES (Sept. 1, 2011), http://www.motherjones.com/environment/2011/09/texas-drought-fracking-water. By 2020, it is estimated that 40 percent of the water in the Eagle Ford's La Salle County will be used for fracking. *See* Kate Galbraith, *Texas Fracking Disclosures to Include Water Totals*, TEX. TRIB., Jan. 16, 2012, http://www.texastribune.org/texas-environmental-news/water-supply/fracking-disclosure-texas-includes-water-volumes/.

requirements or lack thereof.[261] If water has been purchased from a landowner, the only details of the water use are in the contract or not known at all because oil and gas wells are not required to install water meters.[262] In Texas, a new chemical disclosure bill requires water use reporting after the fracking job is complete.[263] While all data is helpful, the retroactive aspect of this law does not solve the problem from a planning perspective.

As in the power industry, bifurcated regulatory agency oversight may preclude the opportunity to make decisions based on all the potential impacts. The consumptive nature of fracking can cause large impacts on water resources, particularly groundwater, over a short period of time, dictating the need for forward planning.[264] To alleviate water consumption concerns, before drilling is commenced, oil and gas companies should coordinate with water regulatory agencies and local districts to project their water demands and identify targeted water sources so that potential problems can be anticipated before well completion.[265] Companies should also be required to install water meters and report their water use in real time to the appropriate governing bodies, even if state law does not require a permit for water access.

On the water supply side, data gaps exist at all points along the water conveyance, delivery, and treatment processes.[266] Very few national studies have quantified the energy requirement of water service, and those studies that

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261. Galbraith, *supra* note 260. A new rule in Texas does require water reporting, but not until the fracking is complete. *Id.* Before this, no statewide reporting was required. *Id.*

262. In some states, oil and gas companies hold significant water rights. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 260, at 26. In Texas, groundwater is owned by the landowner often without permitting requirements; therefore, sale of water to a gas producer is governed by contract law and not monitored by any agency. *See* Edwards Aquifier Auth. v. Day, 369 S.W.3d 814, 817 (Tex. 2012). Although some regions have groundwater conservation districts, state law exempts production wells from their authority. *See* TEX. WATER CODE ANN. § 36.117(b)(2)–(3) (West 2007).

263. H.B. 3328, 82nd Leg., Reg. Sess. (Tex. 2011).

264. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 258, at 13–14.

265. *See id.* at 30–33 (explaining how projected expansion of fracking may impact water resources).

266. *Id.* at 10–11; ETHAN N. ELKIND, UC BERKELEY SCH. OF LAW, ENERGY & THE ENV'T (CLEE), & UCLA SCH. OF LAW, DROPS OF ENERGY: CONSERVING URBAN WATER IN CALIFORNIA TO REDUCE GREENHOUSE GAS EMISSIONS 2 (2011), *available at* http://www.law.berkeley.edu/files/Drops_of_Energy_May_2011_v1.pdf.

have been completed utilized old data.[267] Perhaps the biggest data gap is end uses, which can account for a large amount of energy.[268] Indoor water uses (toilets, showers, and faucets) constitute 60 percent of indoor water needs and most of these uses also require energy to heat water.[269] This includes water-related appliances, which can account for 12.5 percent of home energy use.[270]

The first priority should be installing electric meters at water pumping and treatment locations and along the distribution system.[271] To capture home customer energy use, smart meters that measure household energy required for water heating would be useful.[272] Water providers should gather and report these data. In addition, location-specific information such as water source, quality of the source water, topography of the area, wastewater treatment processes, and distance traveled should be reported because such information is critical in any energy-for-water analysis, particularly for new projects.[273] As with the other data needs described, understanding how much power is being used throughout the water system can help assist planners in selecting water supply measures. Additional data collection and availability in all sectors is the first step in regulating the nexus, but the efficacy of such efforts would depend on the cooperation of energy and water agencies.

B. Coordinating, Communicating, and Sharing

Data collection alone is not sufficient to successfully plan and regulate the energy and water sectors. Even with increased collection and reporting, these sectors are forecasted and controlled separately and report to different government agencies. Although it is likely not possible to blend these agencies into one entity, designated coordination must occur. This coordination should include not only data sharing, but

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267. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 10.
268. *Id.*
269. CTR. FOR SUSTAINABLE SYS., *supra* note 96, at 2.
270. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 7.
271. *See* ELKIND, *supra* note 266, at 15.
272. *See* Jaymi Heimbuch, *How Smart Metering Can Solve the Water Crisis*, HOWSTUFFWORKS, http://science.howstuffworks.com/environmental/conservation/issues/how-smart-metering-can-solve-the-water-crisis.htm (last visited Nov. 30, 2012).
273. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 10.

joint planning and discussion to understand how best to plan major projects in one area with minimal impacts in another. Agency harmonization can also be the source for future policy advances, since these groups are the stakeholders that best understand the situation and are able to predict unintended consequences of proposed legislation.[274]

It is important for any legislation, state or federal, to predetermine the agencies and academic groups that need to be involved. If coverage concerns remain, legislators can include language that allows for the participation of other groups not identified, but the core group must be present. Coordination is certainly not a new concept in this arena.[275] Both the Gordon and Bingaman bills proposed this synchronization between federal agencies for the purposes of a study.[276] While the former did so in an open way and without enumerating participants, the Bingaman bill specifically listed the federal agencies required to partner with DOE in these efforts.[277]

This same type of structure should be prescribed on an ongoing basis. Liaisons should be named from each agency and required to meet for the above-mentioned purposes. In addition to the agencies named in the Bingaman bill, water management organizations such as the Army Corps of Engineers and Bureau of Reclamation need to be included. The national labs that have dedicated significant resources to quantifying these issues can also aid the agencies.

These connections need to be made both before and after data is gathered to ensure consistency and maximum coverage. Currently, federal water data is collected by the USGS and EIA.[278] The latter provides the only national data on water use and cooling technologies at power plants; however, there are some technologies about which EIA does not collect information and databases are often incomplete and inconsistent.[279] Frequency of data collection by these two agencies is also an issue.[280] A concerted effort to fill data gaps in a manner most useful to users would require the agencies involved to

274. *See supra* notes 232–36 and accompanying text.

275. *See* discussion *supra* Part III.C.

276. *See* discussion *supra* Part III.C.

277. *Compare* Energy and Water Research Integration Act, H.R. 3598, 111th Cong. (2009), *with* Energy and Water Integration Act of 2011, S. 1343, 112th Cong. (2011).

278. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 153, at 45–46.

279. *Id.* at 46.

280. *Id.* at 69.

coordinate the timing, frequency, and extent of their collection. They should also be required to harmonize their methodologies so that information gathered from different agencies can be combined for a fuller picture.[281]

Similar efforts need to be made on state and local levels. As with the federal system, water and energy are managed by different groups.[282] The agency tasked with ensuring energy security and calculating reserve margins needs to come together with the water planning organization not only to make sure that there is enough water to support generation, but also to understand water supply infrastructure plans and include them in energy forecasting.[283] At the local level, sector providers should meet in a consistent and organized way to discuss planning and efficiency opportunities. Water providers are often a city's largest energy customer and should be the first stop in any local energy efficiency program.[284] Water-saving incentive and rebate programs can be partially funded by electric providers, and vice versa.[285]

There also needs to be cross collaboration between federal and state agencies.[286] While water data collection may occur on the federal level, water planning is generally a state's obligation.[287] Similarly, while the DOE is tasked with national energy concerns, the U.S. is actually made up of smaller grids,[288] each with its own reliability obligations. In the same way that state and federal agencies partner in the environmental sector,[289] a similar partnership needs to be created at a state level with local water agencies and among the smaller power grids.

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281. ELKIND, *supra* note 266, at 13.

282. *E.g.*, TEX. WATER DEV. BD., http://www.twdb.state.tx.us/ (last visited Nov. 18, 2012); ELEC. RELIABILITY COUNCIL OF TEX., http://www.ercot.com/ (last visited Nov. 18, 2012).

283. *See, e.g.*, Jim Fuquay, *Texas Seeks More Generators*, STAR-TELEGRAM.COM (Apr. 15, 2012), http://www.star-telegram.com/2012/04/14/3883044/texas-seeks-more-generators.html (demonstrating the planning of new energy supply without any obvious consideration for water impacts).

284. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 17.

285. *See* discussion *supra* Part III.A.

286. ELKIND, *supra* note 266, at 17.

287. *See* TEX. WATER CODE ANN. § 11.021 (West 2011).

288. *Visualizing the U.S. Electric Grid*, NAT'L PUB. RADIO, http://www.npr.org/templates/story/story.php?storyId=110997398 (last visited Nov. 18, 2012).

289. *See, e.g.*, Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C.A. §§ 1251–1387 (2012). The Clean Water Act was created using the concept of cooperative federalism and requires a partnership between local and federal governments. *Id.*

Once data collection and agency collaboration have been initiated, policies can be promulgated that specifically regulate one industry in relation to the other, and the established dialogue will ensure their proper implementation.

C. *Conservation, Efficiency, and Renewables*

Sustainability in the energy sector is contingent on sustainability in the water sector, and vice versa. For that reason, policies that promote reducing consumption in either water or energy should be promulgated in order to guard against a crisis in both.[290] There are many ways to achieve this through voluntary, incentivized, and regulated measures.[291] Education and promotion of voluntary programs such as LEED should be encouraged by local, state, and federal policymakers.[292] Buildings and houses that are certified through LEED or another comparable program should be featured in the local press. In addition, new city buildings and facilities should be built to LEED standards to promote recognition of energy-efficient buildings.

City buildings and schools provide great opportunities to demonstrate building efficiency measures.[293] In addition to lowering costs for these public buildings, they can serve as educational tools for students and their visitors. This is particularly impactful in schools because youth can learn about these tools early in their education and integrate them into their lives as adults, thereby developing an important conservation culture. Cities can also encourage builders to utilize these programs by incentivizing them through tax-breaks or zoning variances.

Rebate and incentive programs can also encourage all manner of water and energy use reductions.[294] All cities, particularly medium and large municipalities, should have

290. *See* discussion *supra* Part I.

291. *See* discussion *supra* Part III.A.

292. ELKIND, *supra* note 266, at 16.

293. *See, e.g.*, U.S. GREEN BLDG. COUNCIL, CHAPTER PROJECT PROFILE 1–2 (2009), http://www.usgbc-centraltexas.org/Docs/pdf/LEED%20Profiles/LEED%20Project%20Profile_Austin-City%20Hall.pdf; *Schools/Local Government Energy Program*, STATE ENERGY CONSERV. OFFICE, http://www.seco.cpa.state.tx.us/sch-gov.htm (last visited Nov. 18, 2012) (providing examples of efficient state and city buildings).

294. *See, e.g.*, Hamilton, *supra* note 170; *Indoor Conservation Programs & Rebates*, SAN ANTONIO WATER SYS., http://www.saws.org/conservation/Indoor/ (last visited Nov. 30, 2012).

programs promoting low-flow toilets and faucets, drought resistant foliage and landscaping, and efficient appliances.[295] Comparable programs are available on the energy side.[296] City or municipal agencies should also offer free-home audits that provide efficiency recommendations to homeowners based on inspections by licensed auditors.[297] Although such audits are common for energy usages, they should also be directed at making homes more water efficient as well. These audits have the added benefit of providing an interface between customers and the utility. The inspector can inform citizens of applicable rebate and incentive programs. Home audits could also be required at the point of sale as a way to help homebuyers understand the full costs of their new purchase.[298]

Regulations such as building codes or watering restrictions are important tools in the effort to reduce water and energy demand, particularly in new developments.[299] New builds should be required to implement basic efficiency measures. Also, home renovations and retrofits that involve appliances or household fixtures need to be held to a similar standard. This will lead to an eventual phase-out of old technologies.

The low-flow toilet is a perfect example of market transformation achieved first through voluntary, incentive measures followed by regulatory requirements.[300] Regulations should focus on household appliances, low-flow water fixtures, and building codes for energy needs, such as lighting and

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295. *See, e.g.*, SAN ANTONIO, TEX., ORDINANCES ch. 34, art. IV § 34-271 to -425 (2012).

296. *See, e.g.*, *Energy Conservation Audit and Disclosure (ECAD) Ordinance for Single-Family Homes*, AUSTIN ENERGY, http://www.austinenergy.com/about%20us/environmental%20initiatives/ordinance/single-family.htm (last visited May 10, 2012) (example of such a program) [hereinafter *ECAD*].

297. *Home Energy Audits*, U.S. DEP'T OF ENERGY (Feb. 9, 2011), http://www.energysavers.gov/your_home/energy_audits/index.cfm/mytopic=11160. Costs required to perform the audits can often be regained through the energy saved by the efficiency programs promoted by the auditor as they are adopted by the user. *See, e.g.*, Kristin Underwood, *City of Austin Mandates Home Energy Audits to Avoid Building New Power Plant*, TREEHUGGER (June 8, 2009), http://www.treehugger.com/corporate-responsibility/city-of-austin-mandates-home-energy-audits-to-avoid-building-new-power-plant.html.

298. *E.g.*, *ECAD*, *supra* note 296.

299. *See* discussion *supra* Part III.A.

300. *See, e.g.*, 30 TEX. ADMIN. CODE § 290.252 (1992); *Pinellas County Utilities Alternate Water Sources Rebate Program*, PINELLAS CNTY. GOV'T, http://www.pinellascounty.org/utilities/ulft.html (last visited Nov. 17, 2012); Marty Toohey, *Toilet Rebates Not Cost Effective, City Says in Canceling Program*, STATESMAN.COM (June 29, 2010, 11:23 PM), http://www.statesman.com/news/news/local/toilet-rebates-not-cost-effective-city-says-in-can/nRty5/.

HVAC. As market integration occurs, older technologies should be removed from the marketplace. With these policies, new, more efficient devices will become the norm rather than the exception.

Increasing development of renewable energy as part of the energy profile can have huge impacts on water, both directly and indirectly. Wind and some solar generation technologies require no water at the power production phase, and additional water savings can be gained where these technologies replace traditional generation.[301] Encouraged use of distributed generation through incentives not only reduces demand, but it can actually create a surplus of power that can be sold back to the grid and used by another user.[302]

All of these regulatory options target one sector while impacting the other, but are not promulgated specifically for the purpose of managing both sectors together. While their effect on the other is important, true sustainability cannot be achieved without direct, conjunctive management. Thus, policies can also be passed that specifically target one sector's impact on the other sector.

D. Water for Energy

The goal of this suite of recommended policies is to minimize the amount of water used for energy production, particularly in water stressed areas. In regions without water challenges—a quickly shrinking category—the analysis will be different and other challenges may dictate the technology used. As with the previous sections, the recommendations span from least regulatory to most prescriptive. In a regulation-adverse environment, voluntary or incentive-based options may be more palatable, while more restrictive requirements are aspirational.[303] The goal should be to start the conversation

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301. STILLWELL ET AL., *supra* note 8, at 12 tbl.1.1. Wind energy, photovoltaic solar, and concentrated solar utilizing dry cooling require little to no water for generation. *Id.*

302. *See, e.g.*, Tom Abrahams, *Austin Community Participates in Energy-Saving Study*, ABC13.COM (May 8, 2012), http://abclocal.go.com/ktrk/story?section=news/local&id=8653571. Distributed generation refers to producing energy from many small, on-site energy sources rather than at a large, centralized plant. *Id.*

303. *See generally* RICK PERRY, FED UP!: OUR FIGHT TO SAVE AMERICA FROM WASHINGTON (2010) (discussing objections to federal involvement in states' issues).

and initiate joint planning.

Perhaps the easiest and least controversial policy would be to require a water availability study for any new proposed power generation plants, similar to the legislation that was proposed in Texas.[304] Ideally, report publication would be required upon submission of the air permit application and would include projected water needs, planned water sources for the life of a plant, a list of existing users in the surrounding area, and potential impacts on users and the environment.[305] All information should be submitted to the applicable state agency and be made available to the public. To strengthen this requirement, issuance of an air permit could be made contingent on report submittal.

The purpose of this policy would be two-fold. First, it would increase information about new plants and educate surrounding water users about foreseeable impacts. Under this policy, cooling as well as combustion technologies would still be at the discretion of the producer, but information on their potential impacts would be available early in the construction process when decisions are being made and when design alterations are still possible.

Because the majority of water use in power generation is needed for cooling,[306] policies intended to reduce water use must focus on this aspect of the combustion process. The simplest measure would be to incentivize closed-loop or dry cooling processes, depending on the water needs of the particular region.[307] For areas with fully allocated water resources, the latter would be preferred; however, it is possible that a closed-loop system would be sufficient. Part of the decision process would be the area's need to restrict water withdrawals versus consumptive use by the plant. While a ban on open-loop cooling would greatly reduce the amount of water taken from a water body,[308] it would likely mean that a more consumptive alternative will take its place. State or federal policies that seek to favor one particular technology over others should consider all conditions and impacts before identifying a preference.

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304. *See, e.g.*, H.B. 4206, 81st Leg., Reg. Sess. (Tex. 2009).

305. *See id.*

306. MACKNICK ET AL., *supra* note 38, at 6.

307. Stillwell et al., *supra* note 246, at 7–9. "By implementing alternative cooling technologies at these plants, water diversion could be reduced by as much as 247–703 million m^3 $year^{-1}$ . . . ." *Id.* at 7.

308. STILLWELL ET AL., *supra* note 8, at 12 tbl.1.1.

If something more than incentives is necessary, a particular cooling technology can be required or prohibited based on desired water withdrawal or consumption rates. This would be similar to the California and New York policies to ban once-through cooling to protect fish species.[309] The problem with this approach is that the preferred technology may not always fit the circumstances and can lead to unintended consequences. A more workable alternative mirrors the EPA-proposed rule, which would establish goals and allow the producer to determine how best to meet them.[310]

A more complex, but highly effective option would be a Best Available Control Technology (BACT) consideration for cooling technologies.[311] Unlike simply banning the use of a certain type of technology, this allows an evaluation of many variables including economics, environmental concerns, and plant efficiency impacts.[312] This alternative recognizes that there is not one perfect solution applicable to all regions and environments. Rather, the best cooling technology is dependent on local needs and concerns. In an area with air quality concerns but no water shortages, open-loop cooling may be reasonable; however, in areas with delicate fish ecologies or scarce water resources, open-loop technologies would not survive the BACT analysis.

In the case of water for hydraulic fracturing, policies and regulations could limit the amount of freshwater used by requiring a percentage of on-site recycling of flowback water by

309. *See* discussion *supra* Part III.B.

310. *See* National Pollutant Discharge Elimination System, 76 Fed. Reg. 22174 (proposed Apr. 20, 2011) (to be codified at 40 C.F.R. pts.122, 125).

311. Under the federal Clean Air Act, BACT applies to major sources that emit pollutants subject to the Prevention of Significant Deterioration (PSD) program. *Air Quality Management—Prevention of Significant Deterioration (PSD) and New Source Review (NSR)*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/apti/course422/apc4d.html (last updated Jan. 9, 2010). "The term 'best available control technology' means an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of each such pollutant." 42 U.S.C. § 7479(3) (2006).

312. *See, e.g.*, Stillwell et al., *supra* note 246, at 9 (explaining the parasitic efficiency loss when dry cooling is used, amounting to 1.2 million MWh annually from the nine power plants evaluated, which is worse during hot weather when power is most needed).

the producer or obligating the use of brackish or saline resources where available. Many regions of the country have several water-bearing formations with varying levels of water quality.[313] It is often less expensive for industry to use aquifers developed for drinking water because of existing wells. This approach, however, can dewater or permanently damage these aquifers, which often are needed by other users.[314] Requiring the use of non-potable sources may be more expensive, but is preferable for sustainability purposes both for existing users and drillers.[315] If water is obtained from a distance away from the fracturing site, an additional energy requirement will be needed to transport the water.[316] This should be calculated in the planning process, just as it should in other water supply projects. Similarly, policies need to consider energy used for water projects.

E. Energy for Water

Up to 4 percent of the nation's electricity is used just to move and treat water.[317] This does not include the energy required for the end uses of the water.[318] As water supply projects become more energy intensive, this number is estimated to rise, creating even more of a conflict between sectors.[319] To save energy, water must be the first consideration. "There are three general ways to improve the energy efficiency of water use: reduce the amount of water used for a given task, reduce the energy required to manufacture and deliver each unit of water, or increase the amount of work the water does during its life cycle."[320] Life cycle analysis is important because, by looking at the energy needs at each step in the water use process, one can isolate the areas of greatest potential savings.[321] This can vary based on location. For

313. *See, e.g.*, BUREAU OF ECONOMIC GEOLOGY, UNIV. OF TEX. AT AUSTIN, AQUIFERS OF TEXAS: 2001 (2004), http://www.beg.utexas.edu/UTopia/images/pagesizemaps/aquifer.pdf.

314. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 258, at 13–14.

315. *See, e.g.*, *id.* at 33–37 (stating that water availability issues may hinder shale gas production in some areas).

316. *See id.* at 27.

317. *See* discussion *supra* Part II.B.

318. *See* discussion *supra* Part II.B.

319. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 10.

320. Weissman & Miller, *supra* note 192, at 270.

321. *See id.* at 260–61. Life cycle refers to the manufacture or source removal, transport, distribution, use, and post-use treatment. *Id.* at 260; U.S. GOV'T

example, water sources have a large impact on energy use.[322] Surface water has much lower energy needs because it is more easily accessed compared with groundwater.[323] These factors all require consideration.

In addition to decreasing water usage, there are several recommended policy initiatives that can reduce energy needs in the water sector. Water has become more like a manufactured product than an accessed natural resource as a result of population growth and the increasingly complicated ways that we utilize the substance.[324] Communities are no longer able to meet additional water needs by pumping from nearby rivers or lakes.[325] Existing water supplies are often over-allocated, forcing communities to find nontraditional sources to meet their expanding needs including desalination, water reuse, and long haul transfers.[326] These alternative treatment and conveyance options can greatly increase energy needs if not properly planned.

To avoid unintended consequences, proposed water supply projects need to include energy requirements in their proposals so that they can be evaluated for all possible impacts, including cost and energy security. The easiest way to implement this would be to include energy as a factor for infrastructure loans.[327] Similar to the water availability study for a power plant, the proposing entity would need to identify energy needs, sources, and costs during the application process. This would ensure joint sector planning. If a project would add considerably to a region's power load, this could be identified early on and remedied before problems occur.[328]

In addition to simply lowering the amount of energy required to supply water, management can also reduce

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ACCOUNTABILITY OFFICE, *supra* note 4, at 3 fig.1.

322. *See* discussion *supra* Part II.B.

323. Weissman & Miller, *supra* note 192, at 267.

324. *Id.* at 259–60.

325. *See* discussion *supra* Part I.

326. *See, e.g.*, TEX. WATER DEV. BD., WATER FOR TEXAS 2012 STATE WATER PLAN 13 (2012), http://www.twdb.state.tx.us/publications/state_water_plan/2012/2012_SWP.pdf.

327. *But see Clean Water State Revolving Fund (CWSRF) Loan Program*, TEX. WATER DEV. BD., https://www.twdb.state.tx.us/financial/programs/CWSRF/ (last visited Nov. 3, 2012) (providing an example of a loan program that does not include energy requirements as a consideration for financing).

328. Treating brackish water uses considerably less energy than seawater desalination, but still uses two to three times the energy needed for conventional water treatment. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 15. Understanding these nuances can contribute to water planning discussions.

conflicts. Just like demand management through peak shaving works in the energy sector, it can also work for water. "[I]t might make more sense for an agency to pump water at night during off-peak electricity hours to save money and to avoid using electricity at times of high demand."[329] Policies that create water storage and supply infrastructure should be analyzed against energy needs to see if they can be optimized and used to satisfy both goals.

Increased dependence on water reuse is often cited as a way to save energy by reducing demand of new supply as well as requiring a lower treatment threshold for grey water uses.[330] While this can be true, it is not without exception. If reuse is truly used in lieu of new supply then it is almost certainly going to create an overall energy gain. However, if reuse is just used to add to the per capita water use, then a net loss will occur. Also, although less treatment is required, additional transport may be required; therefore, site-specific variables such as the location of treatment in relation to use and local terrain could change the energy profile for water reuse between locations. Finally, the reuse of previously discharged treated wastewater can also cause problems for downstream users who depend on that flow. Accordingly, all decisions to expand water reuse need to consider other users in the basin.

The appealing aspect of increased use of grey water is that the level of treatment is better matched to the target use.[331] Energy intensive treatment needed to reach drinking water quality standards is not necessary to water yards or fill toilets. Obviously, fully capitalizing on these opportunities would require extensive capital investments to increase infrastructure. Nevertheless, this could have long-term payoffs in water and energy savings.

Other infrastructure upgrades could also make huge energy impacts. It is often beneficial to audit a city's treatment and water management system to identify efficiency

329. Weissman & Miller, *supra* note 192, at 270.

330. *See, e.g.*, Ashlynn S. Stillwell & Michael E. Webber, *Water Conservation and Reuse: A Case Study of the Energy-Water Nexus in Texas*, *in* WORLD ENVIRONMENTAL AND WATER RESOURCES CONGRESS 2010: CHALLENGES OF CHANGE 4093 (2010). Reuse can mean both use of grey water—household water generated from baths, showers, clothes washers, etc.—and reclaimed water, which is treated wastewater effluent. *Id.* at 4095. Because of the additional treatment needed for wastewater, the comments here focus on grey water use.

331. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 13.

opportunities.[332] Many cities still serve their citizens with old, outdated, and inefficient equipment.[333] Minor changes, such as altering the speed of the pumping systems, modifying aeration operations, and right-sizing equipment can result in huge savings without an impact to the customer.[334] Cities should evaluate the availability of these changes and the federal government should incentivize them as part of infrastructure upgrades as well as energy efficiency programs.

When potable water and wastewater treatment utility managers were recently asked what they needed to continue providing services, a common answer was funding for maintenance and replacement of infrastructure.[335] An emphasis was placed on life cycle budgeting and not just funding the construction of new treatment facilities.[336] Again, the upfront costs can often have short payback periods. For example, investing in energy efficient motors and renewables for treatment can reduce energy needs up to 30 percent.[337]

Since the first windmill brought groundwater to the surface, there has been a partnership between renewable energy and water. Renewable technologies can also be used at treatment facilities to reduce the energy provider load.[338] Using the current fuel mix for desalination would increase the environmental footprint of water supply one and a half times; however, the use of solar thermal energy has lower greenhouse gas emissions than importing and recycling water.[339] Options include wind, solar, and capture and reuse of biogas from wastewater treatment facilities.[340] These technologies also reduce air emissions. The critical aspect of any sector decisions is the evaluation of how the proposed project affects all other environmental parameters and weighs those impacts against

332. *Id.* at 20.
333. *See id.* at 12–13.
334. *Id.* at 17–18.
335. *Id.* at 24–25.
336. *Id.*
337. *See id.* at 18.
338. *See id.* at 16, 22; *see also* John Young, *Harnessing Sun and Wind Energy for Water Treatment*, ENVTL. PROT. (May 19, 2010), http://eponline.com/articles/2010/05/19/harnessing-sun-and-wind-energy-for-water-treatment.aspx.
339. Stokes & Horvath, *supra* note 86, at 2680.
340. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 4, at 22; *see also* ASHLYNN S. STILLWELL & MICHAEL E. WEBBER, FEASIBILITY OF WIND POWER FOR BRACKISH GROUNDWATER DESALINATION: A CASE STUDY OF THE ENERGY-WATER NEXUS IN TEXAS 1 (Am. Soc'y of Mech. Eng'rs 4th Int'l Conf. on Energy Sustainability, 2010).

local needs and concerns. Promulgating a variety of measures from these suggestions will aid considerably in society's ability to meet our future water and energy needs without shortages.

CONCLUSION

Energy and water are intricately and crucially linked. Population growth and corresponding demand are creating the opportunity for a collision with significant community consequences including energy blackouts and water shortages. To date, significant policy discussions to prevent these impacts on both the state and federal level have been lacking despite a growing recognition of the relationship from the scientific community.

Appropriate planning can help avoid unintended consequences in related sectors. A critical step in achieving sustainability is to fully understand where energy and water intersect, and to quantify that relationship. This will include almost all water supply and power generation technologies to some extent. Second, these relationships need to be communicated between agencies that have historically operated independently of one another. Third, there needs to be a continued emphasis in education of all parties including policymakers, power producers, and consumers. Conservation should be increased in both sectors. Finally, conjunctive planning and regulation must be implemented.

Added coordination and joint planning among sectors will allow communities to grow and energy generation to proceed in a continuous and sustainable way. Once information is gathered and understood, regional decisions can be made based on local conditions. A broader evaluation of cross-sector implications can ensure long-term sustainability.