Preventing National Electricity-Water Crisis Areas in the United States

Benjamin K. Sovacool* and Kelly E. Sovacool**

* Dr. Benjamin K. Sovacool is a Research Fellow in the Energy Governance Program at the Centre on Asia and Globalization. He is also an Assistant Professor at the Lee Kuan Yew School of Public Policy at the National University of Singapore. He has worked in advisory and research capacities at the U.S. National Science Foundation's Electric Power Networks Efficiency and Security Program, Virginia Tech Consortium on Energy Restructuring, Virginia Center for Coal and Energy Research, New York State Energy Research and Development Authority, Oak Ridge National Laboratory, and U.S. Department of Energy's Climate Change Technology Program. He is the co-editor with Marilyn A. Brown of *Energy and American Society: Thirteen Myths* (2007) and the author of *The Dirty Energy Dilemma: What's Blocking Clean Power in the United States* (2008). He is also a frequent contributor to such journals as *Electricity Journal* and *Energy Policy*. His e-mail address is bsovacool@nus.edu.sg.

** Kelly E. Sovacool is a Senior Research Associate at the Lee Kuan Yew School of Public Policy at the National University of Singapore. She received her MS in geography from the Virginia Polytechnic Institute & State University in Blacksburg, Virginia. Her areas of interest include geopolitical and environmental risk analysis, along with stakeholder identification and assessing the motivations behind natural resource management and environmental law. She is trained in the technical areas of Geographic Information Systems (GIS). Her e-mail address is Simanke@vt.edu.

INTRODUCTION

Imagine if, in 1905, President Theodore Roosevelt had been able to warn President-to-be Franklin D. Roosevelt about the "dust bowl" disaster of the 1930s, which left some 500,000 Americans homeless and destroyed tens of millions of acres of farmland.[1] At the turn of the twentieth century, no one was able to predict that unfettered expansion of farming and destruction of timberland would eventually lead to a severe drought across the Great Plains of America—a region host to a human and ecological catastrophe.[2]

1. *See* Zeynep K. Hansen and Gary D. Libecap, *Small Farms, Externalities, and the Dust Bowl of the 1930's*, 112 J. POL. ECON. 665, 665–94 (2004).

2. *See* T.E. Gill and J.A. Lee, A Critical Evaluation of the Dust Bowl and its Causes,

This article argues that, in a fortuitous twist of fate, we are, in 2009, able to predict (with a reasonable deal of certainty) the likelihood of a similar ecological and human crisis over the next 26 years. That likely crisis stems from the convergence of three separate challenges—population growth, rising electricity demand, and drought. Conventional power plant additions in 2025 in some areas could threaten to cause massive shortages of water, while forced shutdowns could occur due to lack of water in others.[3] The article identifies the most severe locations of these shortages as 22 National Electricity-Water Crisis Areas. This article concludes that the tools needed to prevent these crises are clean power technologies in the form of energy efficiency, wind farms, and solar photovoltaic (PV) panels, and that the President of the United States should immediately issue an executive order to address electricity-water challenges.

Part I of the Article focuses on the electricity-water nexus, and how the existing electricity industry predominately uses what are called "thermoelectric" power plants to transform combustible fuels into usable forms of energy. These plants withdraw about 24.5 gallons of water per every kilowatt-hour (kWh) of electricity produced by diverting water from the water's source; they consume another 0.5 gallons per kWh through evaporative loss.[4] When

Presentation to the American Geophysical Union (Dec. 2006), *available at* http://adsabs.harvard.edu/abs/2006AGUFM.A44C..06G.

3. For a general introduction to future electricity-water challenges, *see generally* Andrew McNemar, Nat. Energy Tech. Lab. (NETL), U.S. Dep't of Energy (DOE), Estimating Freshwater Needs for Thermoelectric Power Plants Through 2030, Presentation at Conference, A Water Constrained Future—How Power Producers Can Minimize the Impact in the West, San Diego, California (May 1–2, 2007) *available at* http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/McNemar2s.pdf; Thomas J. Feeley, NETL, Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements in Western United States, Presentation to the First Western Forum on Energy & Water Sustainability, University of California, Santa Barbara (Mar. 22–23, 2007) *available at* http://www2.bren.ucsb.edu/~keller/energy-water/1-6%20Thomas%20Feeley.pdf.

4. For an excellent introduction into how power plants use water, *see* 3 ELEC. POWER RESEARCH INST. (EPRI), WATER & SUSTAINABILITY: U.S. WATER CONSUMPTION FOR POWER PRODUCTION—THE NEXT HALF CENTURY (2002) [hereinafter EPRI, WATER & SUSTAINABILITY V.3]; Bill Smith, Bob Goldstein, and Keith Carns, Water & Sustainability—The EPRI Research Plan, Presentation to the Water & Sustainability Workshop, Washington, DC (July 25, 2002), *available at* http://www.netl.doe.gov/publications/proceedings/02/EUW/Smith.EPRI%20Water%20&%20Sustainability%20Research%20Plan%207-25-02.pdf; ELLEN BAUM, CLEAN AIR TASK FORCE, WOUNDED WATERS: THE HIDDEN SIDE OF POWER PLANT POLLUTION (2004), *available at*

taken collectively, they withdraw trillions of gallons of water from our rivers and streams.[5] They consume billions of gallons of water from local aquifers and lakes.[6] They require millions of gallons of water to mine, collect, process, enrich, and clean fuel.[7] And, at each step, they degrade water quality by altering its temperature, contaminating it with mercury and particulate matter, and shifting where it falls and flows through direct usage and indirectly-induced climate change.[8] Thermoelectric power plants, which run on coal, natural gas, oil, and uranium, thus require immense amounts of water to cool the combustion process.[9]

Part II of the Article identifies 22 National Electricity-Water Crisis Areas. Using data on population growth, plans for future power plant construction, and summer water shortages collected from the U.S. Census Bureau, U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Energy (DOE), along with a bit of sophisticated modeling, this section predicts that severe water shortages related to electricity will occur in at least 22 counties covering 20 major metropolitan areas by 2025. Failure to address future water-electricity challenges in these areas could risk significant increases in water prices along with the possibility of billions of dollars in damages.

Part III demonstrates the inadequacy of current approaches towards addressing electricity and water needs. It notes that despite the seriousness of water concerns associated with electricity use, most electric utilities continue to propose water-intensive power plants as the best way to meet demand projections. Research being conducted at various industry and national laboratories on alternative thermoelectric cooling systems, untraditional sources of water, water capture at existing power

http://www.catf.us/publications/reports/Wounded_Waters.pdf; DOE, ENERGY DEMANDS ON WATER RESOURCES: REPORT TO CONGRESS ON THE INTERDEPENDENCE OF ENERGY AND WATER 36–39 (2006) [hereinafter DOE, ENERGY DEMANDS].

5. *See* EPRI, WATER & SUSTAINABILITY V.3, *supra* note 4 p. viii (Table S-1); DOE, ENERGY DEMANDS, *supra* note 4, at 10 (hundreds of millions of gallons for coal and gas power plants), 20 (more than 3 trillion gallons for hydroelectric plants); McNemar, *supra* note 3, at 15; Feeley, *supra* note 3, at 8.

6. *Id.*

7. *Id.*

8. BAUM, *supra* note 4, at 12.

9. *See* EPRI, WATER AND SUSTAINABILITY V.3, *supra* note 4 at viii (Table S-1).

plants, and clean coal technologies will likely reduce water use at conventional power plants. However, due to long lead times, complexities in the R&D process, and uncertain funding, these efforts will likely be insufficient to abate future water shortages on their own.

Part IV of the Article makes the case that the President should issue an Executive Order designating 22 regions of the United States as "National Electricity-Water Crisis Areas," placing an immediate moratorium on future thermoelectric power plants in these zones, authorizing the creation of a National Electricity Water Policy Surcharge to fund additional research, and establishing a National Electricity Water Policy Program Office at the Federal Energy Regulatory Commission. One of the first tasks for this Program Office would be to improve the quality of research related to electricity and water shortages.

I. THE ELECTRICITY-WATER NEXUS

Thermoelectric power plants—those relying on the combustion of fuels such as oil, natural gas, and biomass/waste, or the use of uranium in nuclear reactors—primarily use water in two ways: they "withdraw" it from rivers, lakes, and streams to cool equipment before returning it to its source, and they "consume" it through evaporative loss.[10] The term "consumption" means water is removed entirely from the water table, whereas the term "withdraw" means that it is returned to the water table albeit usually in a slightly different form (i.e., at a higher temperature or with chemicals or contaminants that were used in the cooling process). For the sake of simplicity, and because many of the reports and sources of data we collected for this article did not make distinctions between water consumption and water withdrawals and instead merely used the term "use," we have done the same at most points throughout the text. Thus water "use" is meant to imply both consumption and withdrawals together unless otherwise noted.

10. DOE, ENERGY DEMANDS, *supra* note 4, at 9-10.

A. Thermoelectric Cooling Cycles

Almost all conventional power plants employ one of two types of fuel cycles in their generation of electricity.[11] Once-through cooling systems withdraw water from a source, circulate it, and return it to the surface body.[12] Re-circulating, or closed-loop, systems withdraw water and then recycle it within the power system rather than discharge it.[13]

As their name implies, once-through cooling systems, or "open-loop" systems, only use water once, as it passes through a condenser to absorb heat. Plant operators commonly add chlorine intermittently to control microbes that corrode pipes and materials. Operators may also add several toxic and carcinogenic chemicals such as hexavalent chromium and hydrazine.[14] After it passes through the plant, heated and treated water is then discharged downstream from its point of intake to a receiving body of water. Since such cooling systems release heated water back to the source, they can contribute to evaporative loss by raising the temperature of receiving water bodies.[15] Once-through cooling systems are more common in the Eastern U.S.[16] Once-through systems withdraw about 91 percent of the nation's water used for power plants, and fifty-nine of the country's 103 nuclear reactors rely on this type of cooling, each drawing as much as one billion gallons of water into its cooling system per day (or more than 500,000 gallons a minute).[17]

Re-circulating or closed-loop systems, by recycling water, withdraw much less of it but tend to consume more.[18] Since it is being reused, the water also requires more chemical treatment to eliminate naturally occurring salts and solids that accumulate as

11. *See* 1 EPRI, WATER & SUSTAINABILITY: RESEARCH PLAN 2-12 (2002).

12. *Id.*

13. *Id.*

14. BAUM, *supra* note 4, at 2.

15. *Id.* at 3.

16. *See* CLEAN AIR TASK FORCE & LAND AND WATER FUND OF THE ROCKIES, THE LAST STRAW: WATER USE BY POWER PLANTS IN THE ARID WEST at 4 (noting closed-cycle cooling systems are used mostly in the West, once-through in the East) (2003), *available at* http://www.catf.us/publications/reports/The_Last_Straw.pdf.

17. LINDA GUNTER ET AL., LICENSED TO KILL: HOW THE NUCLEAR POWER INDUSTRY DESTROYS ENDANGERED MARINE WILDLIFE AND OCEAN HABITAT TO SAVE MONEY 1 (2001).

18. BAUM, *supra* note 4, at 3.

water evaporates.[19] To maintain plant performance, water is frequently discharged from the system at regular intervals into a reservoir or collection pond.[20] Plant operators call this water cooling-tower blowdown.[21] Once the plants release blowdown, operators treat fresh water with chlorine and biocides before it enters the cooling cycle.[22] Closed-loop systems rely on greater amounts of water for cleaning and therefore return less water to the original source.[23] Closed-loop systems are more common in the Western U.S.[24]

In aggregate, the water intensity of thermoelectric power plants is presented in Table 1.

Table 1: Water Intensity of Thermoelectric Power Generators in gallons per Kilowatt-Hour (gWh) equivalent (gal/gWhe)[25]

Fuel	Cooling Process	Withdrawals (gal/gWhe)	Consumption (gal/gWhe)
Fossil/ biomass/waste	Once-through cooling	20 to 50	~0.30
Fossil/ biomass/waste	Closed-loop tower	0.30 to 0.60	0.30 to 0.48
Fossil/ biomass/waste	Closed-loop pond	0.50 to 0.60	~0.48
Nuclear	Once-through cooling	25.00 to 60.00	~0.40
Nuclear	Closed-loop tower	0.50 to 1.10	0.40 to 0.72
Nuclear	Closed-loop	0.80 to 1.10	~0.72

19. *Id.*
20. *Id.*
21. *Id.*
22. *Id.*
23. *See* DOE, NO. DOE/GO-102006-2218, THE WIND/WATER NEXUS 2 (2006) [hereinafter DOE, WIND/WATER NEXUS].
24. BAUM, *supra* note 4, at 4.
25. *See* DOE, ENERGY DEMANDS, *supra* note 4, at 38.

	pond		
Geothermal steam	Closed-loop tower	~2.00	~1.40
Solar trough	Closed-loop tower	0.76 to 0.92	0.76 to 0.92
Solar tower	Closed-loop tower	~0.75	~0.75
Natural gas combined cycle	Once-through cooling	7.50 to 20.00	0.10
Natural gas combined cycle	Closed-loop tower	~0.23	~0.18
Coal gasification (IGCC)	Closed-loop tower	~0.25	~0.20

B. Thermoelectric Water Use in the United States

In the United States, nuclear plants use the most water at a rate of about 43 gallons of water for every kWh generated;[26] coal and waste-incineration plants use about 36 gallons of water for every kWh generated;[27] natural gas plants use about 14 gallons of water for every kWh generated,[28] while the industry average is 25 gallons of water for every kWh generated.[29]

The numbers may not sound like much, but they quickly add up. Coal-fired power stations generated 1,957 billion kWh in 2006, equating to the use of 52.8 trillion gallons of water; nuclear units generated 787 billion kWh and used 33.8 trillion gallons; natural gas plants produced an additional 877 billion kWh and 12.3 trillion gallons.[30] Based on the most recent data available from the USGS,

26. *See* DOE, ENERGY DEMANDS, *supra* note 4, at 65; BAUM, *supra* note 4, at 4.
27. *Id.*
28. *Id.*
29. Thomas J. Feeley and Massood Ramezan, Presentation at the Water Environment Federation, 9th Annual Industrial Wastes Technical and Regulatory Conference, Electric Utilities and Water: Emerging Issues and R&D Needs (Apr. 13–16, 2003), *available at* http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/WEF%20Paper%20Final%20header_1.pdf.
30. U.S. ENERGY INFO. ADMIN. (EIA), DOE, 2007 ELECTRIC POWER ANNUAL, Tbl.ES1, Summary Statistics for the United States 1996 through 2007, *available at* http://www.eia.doe.gov/cneaf/electricity/epa/epaxlfilees1.pdf.

thermoelectric power plants used more than 195 billion of gallons of water per day, or 47.8 percent of the country's total.[31] This means that, on average, thermoelectric generators used more water than the entire country's agricultural and horticultural industry, which encompasses the nation's irrigation, frost protection, field preparation, cropping, and maintenance of golf courses, parks, nurseries, cemeteries, and self-supplied landscaping needs.[32]

The water use of some particular power plants is even more striking. A conventional 500 MW coal plant, for instance, consumes about 7,000 gallons of water per minute, or the equivalent of 17 Olympic-sized swimming pools every day.[33] The coal-fired 1,800 MW San Juan Generating Station, operated by the Public Service of New Mexico, uses 7.3 billion gallons of water per year from the San Juan River.[34] One nuclear plant in Georgia withdraws an average of 57 million gallons every day from the Altamaha River, but actually consumes 33 million gallons per day from the local supply (primarily as lost water vapor), which would be enough to service more than 196,000 Georgia homes.[35] The Shearon Harris nuclear reactor, operated by Progress Energy in New Hill, North Carolina (near Raleigh), sucks up 33 million gallons a day (and loses 17 million gallons per day due to evaporation). Duke Energy's McGuire Plant on Lake Norman, North Carolina, draws in more than 2 billion gallons of water per day.[36] Southern Company's Joseph M. Farley nuclear plant in

31. SUSAN S. HUTSON ET. AL., U.S. GEOLOGICAL SURVEY (USGS), U.S. DEP'T OF INTERIOR, ESTIMATED USE OF WATER IN THE UNITED STATES IN 2000 40 (2004), *available at* http://pubs.usgs.gov/circ/2004/circ1268/pdf/circular1268.pdf.

32. *Id.* at 20, 40.

33. Thomas J. Feeley, NETL, Tutorial on Electric Utility Water Issues, Presentation at the 28th International Technical Conference on Coal Utilization and Fuel Systems (Mar. 10–13, 2003), *available at* http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/Clearwater031003.pdf.

34. *See* KENT ZAMMIT & MICHAEL N. DIFILIPPO, EPRI, USE OF PRODUCED WATER IN RECIRCULATING COOLING SYSTEMS AT POWER GENERATION FACILITIES, SEMI-ANNUAL TECHNICAL PROGRESS REPORT DELIVERABLE NUMBER 6, JULY 26, 2004 TO NOVEMBER 19, 2004 at p. 3 in the abstract, *available at* http://www.netl.doe.gov/technologies/coalpower/ewr/water/pp-mgmt/pubs/41906/41906CostBenefitAnalysis.pdf (noting that the plant uses 22,400 acre feet of water per year; 22,400 acre feet = 7.3 billion gallons).

35. *See* SARA BARCZAK & RITA KILPATRICK, S. ALLIANCE FOR CLEAN ENERGY, ENERGY IMPACTS ON GEORGIA'S WATER RESOURCES 1 (2007), *available at* http://cms.ce.gatech.edu/gwri/uploads/proceedings/2003/Barczak%20and%20Kilpatrick.PDF.

36. Mitch Weiss, *Drought Could Force Nuke-Plant Shutdowns*, USA TODAY, Jan. 25, 2008, *available at* http://www.usatoday.com/weather/drought/2008-01-24-drought-power_N.htm.

Dothan, Alabama, consumes about 46 million gallons of water per day (primarily as evaporative loss).[37]

In the arid West, where water is scarce, the challenge of cooling nuclear plants is even more daunting. The Palo Verde plant in Arizona is capable of processing 90 million gallons of water for its cooling needs at the plant site each day.[38] Plant operators must purchase treated effluent from seven cities in the Phoenix metropolitan area, and had to construct a 35-mile pipeline to carry water from a treatment facility to the plant—which received 22.5 billion gallons of treated effluent in 2000.[39]

To their credit, utilities and system operators have drastically improved the water-efficiency of the electricity industry so that consumption is falling in per-capita terms. Largely through the installation of more efficient cooling systems and water conservation efforts, the industry has reduced its water needs by 40 percent between 1970 and 1995.[40] In 1950, for example, about 63 gallons of water were withdrawn to produce every kWh of electricity, while today that number is 21 gallons per kWh (looking at withdrawals only, not withdrawals and consumption).[41] All the while, the industry has increased output of electric power by a factor of fifteen.[42]

Despite these improvements in efficiency, the industry's water use is still rising in absolute terms: water use for electric power plants increased five-fold from 14.6 trillion gallons in 1950 to 71

37. Press Release, S. Alliance for Clean Energy, Energy Group Urges Planning for Droughts: Avoid Nuclear and Coal Water Hogs 2 (Oct. 25, 2007), *available at* http://64.84.47.47/sights/cleanenergy/mediaRoom/docs/SACEdroughtElectricityPR102507.doc.

38. PINNACLE WEST CAPITAL CORP., 2006 CORPORATE RESPONSIBILITY REPORT: WATER MANAGEMENT, http://www.pinnaclewest.com/main/pnw/AboutUs/commitments/ehs/2006/ehs/water/default.html (last visited Mar. 13, 2009).

39. PINNACLE WEST CAPITAL CORP., 2000 APS ENVIRONMENTAL, HEALTH, AND SAFETY REPORT 37 (2001), *available at* http://www.pinnaclewest.com/files/ehs/2000/EHS2000_FullReport.pdf

40. JILL BOBERG, RAND CORP., LIQUID ASSETS: HOW DEMOGRAPHIC CHANGES AND WATER MANAGEMENT POLICIES AFFECT FRESHWATER RESOURCES 34 (2005), *available at* http://www.rand.org/pubs/monographs/2005/RAND_MG358.pdf (citing Peter H. Gleick, *The Changing Water Paradigm*, 25 WATER INT'L 127, 129 (2000).

41. *See* HUTSON ET AL., *supra* note 31, at 42 (citing WAYNE B. SOLLEY ET AL., USGS, ESTIMATED USE OF WATER IN THE U.S. IN 1995 62–64 (1998), *available at* http://water.usgs.gov/watuse/pdf1995/pdf/circular1200.pdf).

42. *See id.* (citing EIA, NO. DOE/EIA-0384 (2002), ANNUAL ENERGY REVIEW 2002 221–238 (2003), *available at* http://tonto.eia.doe.gov/FTPROOT/multifuel/038402.pdf).

trillion gallons in 2000 and about 90 trillion gallons in 2007. [43] While efficiency of water use at power plants improved significantly during this period, increased demand for electricity placed a growing burden on water supplies. Already, today, 23,000 gallons of water are needed to produce the electricity an average American home consumes in one month.[44]

While newer technologies withdraw less water, they actually consume more. Advanced power plant systems that rely on re-circulating, closed-loop cooling technology convert more water to steam that is vented to the atmosphere.[45] Closed-loop systems also rely on greater amounts of water for cleaning and therefore return less water to the original source.[46] Thus, even though modern power plants may reduce water withdrawals by up to 10 percent, they contribute even more to the nation's water scarcity.

Furthermore, the electricity industry's impact on water resources extends well beyond merely withdrawing and consuming it at power plants. As the following subsections illustrate, other parts of thermoelectric fuel cycles, such as coal mining, oil and gas production, and uranium fuel processing, can require (and degrade or contaminate) up to 4.5 gallons for every kWh of electricity generated.[47] (See Table 2.)

Table 2: Upstream Water Intensity of Conventional Power Plants in gallons per kWh equivalent (gal/kWhe)

Fuel	Process	Withdrawals (gal/kWhe)	Consumption (gal/kWhe)
Coal	Mining		0.005 to 0.007
Coal	Slurry	0.11 to 0.23	0.003 to

43. *See* HUTSON ET AL., *supra* note 31, at 41 fig.14 for data on water use in 1950 and 2000. Water use for 2007 was calculated by taking the kWh reported for generation in 2007 and multiplying it by 25 gallons per kWh, the industry average. The kWh reported for 2007 (3,810,454 thousand megawatt hours) taken from U.S. EIA, Table 1.1, at http://www.eia.doe.gov/cneaf/electricity/epm/table1_1.html.

44. BENJAMIN SOVACOOL, THE DIRTY ENERGY DILEMMA: WHAT'S BLOCKING CLEAN POWER IN THE UNITED STATES 1 (2008).

45. DOE, WIND/WATER NEXUS, *supra* note 23, at 2.

46. *Id.*

47. *See* DOE, ENERGY DEMANDS, *supra* note 4, at 38 tbl.V-1.

			0.007
Nuclear	Mining and Processing		0.005 to 0.015
Natural Gas	Supply		0.001
Clean Coal	Process Water	0.13	0.001
Hydroelectric	Evaporation		4.5

C. Coal mining

The United States is home to roughly 2,100 coal mines currently operating in 27 states.[48] In 2005, they mined 1.131 trillion short tons of coal.[49] The DOE estimates that such mining activities use an additional 70 to 260 million gallons of water per day.[50] Coal mining techniques naturally vary across the country based on geology and chemical composition of the rock and landscape, proximity to local water resources, mining methods, environmental regulations, types of coal, and extraction processes.[51] Western coal is generally lower in sulfur content than eastern coal, but it also has a poorer heating value, meaning that more coal is needed to produce power.[52] Due to the shallow nature of most western coal deposits, surface mining methods dominate coal mining in that region, making them less water intensive than their eastern counterparts, which rely on underground mining.[53] In the western U.S., ninety percent of mining is surface mining, whereas in Appalachia sixty-five percent is underground mining.[54]

In either case, water is needed to wash coal, remove sulfur, suppress dust, and reclaim vegetation for the surface. Depending on the mining techniques used, mines use between 10 and 150

48. Mine Safety and Health Admin., U.S. Dep't of Labor, Coal Mine Safety and Health, http://www.msha.gov/programs/coal.htm (last visited Mar. 13, 2009).

49. *See* EIA., INTERNATIONAL ENERGY ANNUAL 2006, fig.2.5 (2006), http://www.eia.doe.gov/pub/international/iealf/table25.xls (last visited Mar. 13, 2009).

50. DOE, ENERGY DEMANDS, *supra* note 4, at 55.

51. NETL, NO. DOE/NETL-2006-1233, EMERGING ISSUES FOR FOSSIL ENERGY AND WATER 10 (2006), *available at* http://www.netl.doe.gov/technologies/oil-gas/publications/AP/IssuesforFEandWater.pdf [hereinafter NETL, EMERGING ISSUES].

52. *See* DOE, ENERGY DEMANDS, *supra* note 4, at 53–55.

53. *See id.* at 10.

54. *See* NETL, EMERGING ISSUES, *supra* note 51, at 11.

gallons per ton of processed coal.[55] The DOE estimated that, in 2000, overall water required for coal washing and mining was roughly between four and twelve percent of freshwater withdrawals for the entire mining sector.[56] Coal mines also affect water quality and surrounding water resources. Underground and surface mines require the removal of material, topsoil, soil, and rocks in order to access coal.[57] These materials "are stored in piles that are exposed to natural weather events, allowing for oxidation of trace elements into acids or alkyls that leach into surface waters via water runoff and snow."[58] The problem has become particularly acute in the west, where prolonged large-scale area surface mining occurs. Western coals are often a significant part of a local aquifer, meaning that the removal of coal disrupts the natural recharge rate of the hydrological system.[59] In addition, reclaimed areas in the west can be porous when it rains, allowing percolating water to leach pollutants through soil and into underground aquifers.[60] Compressing the fill to reduce leaching only leads to lower recharge rates for the aquifer[61]—a tenuous dilemma that forces mining managers to either directly pollute aquifers or greatly lower their natural recharge rates.

Mountaintop removal—a more recent technique for coal extraction that uses heavy explosives to blow apart the tops of mountains—has degraded streams and blighted landscapes, and reduced the water quality of communities.[62] Coal slurry impoundments that fail, contaminated water, and occupational hazards (such as mine-related deaths and injuries) are among the social consequences of continued dependence on coal-fired power plants.[63] In Pennsylvania, where twenty-five percent of the nation's historical coal production has occurred, drainage from abandoned coal mines has contaminated several thousand miles of surface

55. *Id.*
56. *Id.* at 12.
57. *Id.*
58. *Id.*
59. *Id.*
60. *Id.* at 13.
61. *Id.*
62. Benjamin K. Sovacool, *Coal and Nuclear Technologies: Creating a False Dichotomy for American Energy Policy*, 40 POL'Y SCI. 101, 110–112 (2007).
63. SOVACOOL, *supra* note 44, at 66.

streams and groundwater with acids, metals, and sediment.[64]

D. Oil and Natural Gas Production and Refining

Oil and natural gas combine to provide roughly 20.5 percent of the country's electricity (1.5 percent for oil and 19 percent for natural gas).[65] The DOE estimates that the fuel production facilities needed to refine oil use about one to two billion gallons of water per day; those for natural gas use about 400 million gallons of water per day.[66]

Again, however, the true water impacts from oil and gas production are not limited to water use. The USGS estimated that there are more than two million oil and natural gas wells in the domestic U.S.[67] The most intense areas of oil and gas production are off the shores of the Gulf of Mexico and along the northern coast of Alaska.[68] The process of onshore oil production injects water into oil reserves to create extra pressure needed to push oil to the surface. As a result, offshore oil and natural gas exploration and production in the Gulf of Mexico leach chemicals into water sources by discharging drilling mud and cuttings, and also continually release low levels of hydrocarbons around production platforms.[69]

Liquefied Natural Gas (LNG) terminals bring their own assortment of water-related impacts, including the risk of harming local fish populations during routine operation, introducing invasive species from ballast water, and discharging toxic substances

64. USGS, COAL-MINE-DRAINAGE PROJECTS IN PENNSYLVANIA, http://pa.water.usgs.gov/projects/amd/ (last visited Mar. 13, 2009).

65. EIA, 2007 ELECTRIC POWER ANNUAL, *supra* note 30, at 16–17 tbl.1.1, Net Generation by Energy Source by Type of Producer, 1996 through 2007, *available at* http://www.eia.doe.gov/cneaf/electricity/epa/epa.pdf. (Precise percentages based on the author's calculations).

66. DOE, ENERGY DEMANDS, *supra* note 4, at 20 (citing Peter H. Gleick, *Water and Energy*, 19 ANN. REV. ENERGY & ENV'T 284, tbl.5 (1994); EIA, NO. DOE/EIA-0383, ANNUAL ENERGY OUTLOOK 2006 (2006)).

67. USGS, NATIONAL OIL AND GAS ASSESSMENT, http://geology.usgs.gov/connections/blm/energy/o&g_assess.htm (last visited Feb. 2, 2009).

68. *Id.*

69. Charles H. Peterson et al., *Ecological Consequences of Environmental Perturbations Associated With Offshore Hydrocarbon Production: A Perspective on the Long-Term Exposures in the Gulf of Mexico*, 53 CAN. J. FISHERIES & AQUACULTURE SCI. 2637, 2637–2654 (1996).

into the watershed.[70] The construction of the proposed Broadwater Energy Project, an eight billion cubic feet large marine LNG terminal and underwater natural gas pipeline intended for Long Island Sound, would discharge approximately four million gallons of hydrostatic seawater treated with biocide.[71] The facility, once operating, would also utilize pollution control equipment that would discharge about 11 million gallons of brackish water every five years. During normal operation, Broadwater would withdraw about 28.2 million gallons per day of seawater, resulting in an estimated loss of 274 million fish eggs and larvae annually.[72] The facility would also risk bringing invasive species to Long Island Sound from the ballast water of LNG tankers.[73] The New York State Department of Environmental Conservation has warned that going ahead with Broadwater would create a "significant adverse impact to the aquatic environment and fishery of the Long Island Sound."[74]

LNG re-gasification facilities typically release daily discharges of sodium hypochlorite (chlorine bleach) and wastewater during their operation. The lighting of LNG facilities can attract organisms, especially mollusks and marine invertebrates, from many miles away, only to suck them into intake structures where they are impinged and entrained (for more on impingement and entrainment, see Part 1.6). For these reasons, estimates of mortality rates for fish and marine species associated with LNG facilities may be underestimated by a factor of ten.[75] The environmental impact assessment for the proposed Port Pelican

70. *See* Broadwater Energy Project, DEC No.1-4799-0007/0001 (N.Y. Dep't of Envt'l Conserv. Feb. 8, 2008) (notice of incomplete application) (on file with author) [hereinafter Broadwater Energy Project, Feb. 8, 2008 Notice]; Broadwater Energy Project, DEC No.1-4799-0007/0001 (N.Y. Dep't of Envt'l Conserv. Dec. 21, 2007) (notice of incomplete application) (on file with author) [hereinafter Broadwater Energy Project, Dec. 21, 2008 Notice].

71. Broadwater Energy Project, Feb. 8, 2008 Notice, *supra* note 70, at 6.

72. Broadwater Energy Project, Dec. 21, 2007 Notice, *supra* note 70, at 13; Broadwater Energy Project, Feb. 8, 2008 Notice, *supra* note 70, at 2.

73. Memorandum from Stephen T. Tettelbach, Professor of Biology, C.W. Post Campus of Long Island University, for Citizens Campaign for the Environment, Comments on the Broadwater LNG Project Draft Environmental Impact Statement (January 8, 2007), http://www.citizenscampaign.org/PDFs/Broadwater.Draft.EIS.pdf (last visited Mar. 13, 2009).

74. Broadwater Energy Project, Dec. 21, 2007 Notice, *supra* note 70, at 14.

75. Tettelbach, *supra* note 73.

Liquid Natural Gas processing facility on the coast of Louisiana, for instance, found that the entrainment from normal operation would effectively "sterilize" the entire water column around the facility.[76]

E. Uranium Mining and Leaching

The country's 103 operational commercial nuclear power plants provide roughly 19.4 percent of the nation's electricity.[77] These plants rely on a collection of uranium mines and enrichment facilities for usable fuel. Since the bulk of these mining and processing facilities are outside of the U.S., the DOE estimates that only three to five million gallons of water per day are associated with mining and processing within the country.[78]

Still, uranium mining, the process of extracting uranium ore from the ground, is extremely water intensive. Since quantities of uranium are mostly prevalent at very low concentrations, uranium mining is volume intensive.[79] Early mining techniques were very similar to other hard rock mining such as copper, gold, and silver, and involved the creation of underground mines.[80] Open-pit mining, the most prevalent type of uranium extraction in the world today, ceased in the United States in 1992 due to concerns about environmental contamination and the quality of uranium, as most uranium ore found in the U.S. was lower grade from sandstone deposits.[81] Currently, uranium miners use only one type of

76. Memorandum from Nancy B. Thompson, Potential Impacts of Liquid Natural Gas Processing Facilities on Fishery Organisms in the Gulf of Mexico, at 7 (2004).

77. EIA, 2007 ELECTRIC POWER ANNUAL, *supra* note 30, at 9.

78. DOE, ENERGY DEMANDS, *supra* note 4, at 23.

79. For an overview of uranium mining and the front end of the nuclear fuel cycle, *see* Benjamin K. Sovacool, *Valuing the Greenhouse Gas Emissions from Nuclear Power: A Critical Survey*, 36 ENERGY POL'Y 2940, 2941–2943 (2008) [hereinafter Sovacool, *Greenhouse Gas Emissions*].

80. *Id.*

81. *See* EPA, URANIUM MINING AND EXTRACTION PROCESSES IN THE UNITED STATES 2-4–2-5 (2006), *available at* http://www.epa.gov/radiation/docs/tenorm/402-r-08-005-voli/402-r-08-005-v1-ch2.pdf ("Conventional refers to open-pit and underground mining. Open-pit mining is employed for ore deposits that are located at or near the surface, while underground mining is used to extract ore from deeper deposits or where the size, shape, and orientation of the ore body may permit more cost-effective underground mining. Since the early 1960s, most uranium has been mined on a larger scale than earlier mining efforts, and, until recently, by using conventional mining techniques. Radioactive mine wastes from conventional open-pit and underground mines are considered to be TENORM, whose regulatory responsibility resides with EPA or the states. In recent years, ISL operations

technique to extract uranium ore in Wyoming, Nebraska, and Texas: in-situ leaching.[82]

Uranium miners perform in-situ leaching by pumping liquids into the area surrounding uranium deposits.[83] These liquids often include acid or alkaline solutions to weaken the calcium or sandstone surrounding uranium ore.[84] Operators then pump the uranium up into recovery wells at the surface, where it is collected.[85] In-situ leaching was deemed more cost effective than underground mining because it avoids the significant expense of excavating underground sites and often takes less time to implement.[86] Nonetheless, it uses significantly more water—as much as seven to eight gallons for every kWh of nuclear power generated from U.S.-based uranium.[87]

F. Power Plant Construction

Even constructing large fossil-fueled and nuclear power plants can have significant water-related needs and impacts. Some of the largest power plant components, such as turbines, boilers, and reactor cooling towers, have special shipping requirements. In Georgia, billions of gallons of water had to be released from Lake Lanier to raise water levels on the lower Chattahoochee River so that replacement steam generators could be shipped to the Farley nuclear power plant near Dothan, Alabama.[88] The Army Corps of Engineers even had to design and maintain a shipping channel from Savannah, Georgia to August, Georgia so that power plant equipment could be moved on the river.[89] Since maintenance on the deepwater channel ended in 1979 and Lake Lanier is currently running low on water, power plant operators have warned that rivers in some parts of the South would have to be dredged to allow

(regulated by the NRC or its Agreement States) in the United States are described further below. Those operations have generally replaced conventional mining because of their minimal surface disturbance and avoidance of associated costs.").

82. *Id.* at 13.

83. Sovacool, *Greenhouse Gas Emissions, supra* note 79, at 2.

84. *Id.*

85. *Id.*

86. EPA, TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIALS FROM URANIUM MINING 92, AIII-1–AIII-2 (2008).

87. DOE, ENERGY DEMANDS, *supra* note 4, at 56.

88. Rob Pavey, *Reactors May Ride on River*, AUGUSTA CHRON., June 5, 2008, at B1.

89. *Id.*

reactor upgrades and construction of new large power plants to occur.

As the next few subsections will show, further water waste and contamination occurs at multiple points of the generation cycle: at the point of intake, at the point of discharge, at the fuel storage site, and during cleaning and maintenance.

G. Impingement and Entrainment

At the point of intake, thermoelectric plants bring water into their cooling cycles through specially designed structures. To minimize the entry of debris, water is often drawn through screens.[90] Seals, sea lions, endangered manatees, American crocodiles, sea turtles, fish, larvae, shellfish, and other riparian or marine organisms are frequently killed as they are trapped against the screens in a process known as impingement.[91] Organisms small enough to pass through the screens can be swept up in the water flow where they are subject to mechanical, thermal, and toxic stress in a process known as entrainment.[92] Billions of smaller marine organisms, essential to the food web, are sucked into cooling systems and destroyed.[93] Smaller fish, fish larvae, spawn, and a tremendous volume of other marine organisms are frequently pulverized by reactor condenser systems.[94] One study estimated that more than ninety percent are scalded and discharged back into the water as lifeless sediment that clouds the water around the discharge area, blocking light from the ocean or river floor which further kills plant and animal life by curtailing light and oxygen.[95] During periods of low water levels, power plants induce even more environmental damage; nuclear plants, for instance, must extend intake pipes further into rivers and lakes, but as they approach the bottom of the water source, they often suck up sediment, fish, and other debris.[96] Impingement and entrainment consequently account for substantial losses of fish and exact severe

90. *See* BAUM, *supra* note 4; GUNTER ET AL., *supra* note 17.
91. BAUM, *supra* note 4, at 8.
92. *Id.*
93. GUNTER ET AL., *supra* note 17, at 8.
94. *Id.* at 10.
95. *Id.*
96. Weiss, *supra* note 36, at 1.

environmental consequences.

For example, federal environmental studies of entrainment during the 1980s at five power plants on the Hudson River in New York—Indian Point, Bowline, Roseton, Lovett, and Danskammer—estimated grave year-class reductions in fish populations (the percent of fish killed within a given age class).[97] Authorities noted that power plants were responsible for age reductions as high as seventy-nine percent for some species, and an updated analysis of entrainment at three of these plants estimated year-class reductions of twenty percent for striped bass, twenty-five percent for bay anchovy, and forty-three percent for Atlantic tom cod.[98] Other researchers have evaluated entrainment and impingement impacts at nine facilities along a 500-mile stretch of the Ohio River.[99] The researchers estimated that approximately 11.6 million fish were killed annually through impingement and 24.5 million fish from entrainment.[100] The study calculated recreational related losses at about $8.1 million per year.[101]

The U.S. Environmental Protection Agency (EPA) calculated impingement losses from power plants operating near the Delaware Estuary Watershed at more than 9.6 million age-one equivalents of fish every year, or a loss of 332,000 pounds of fishery yield.[102] The EPA figured that entrainment-related losses were even larger; those losses amounted to 616 million fish, or a loss of 16 million pounds of catch.[103] Put into monetary value, the recreational fishing losses from impingement and entrainment were estimated to be about $5 million per year.[104]

Scientists also estimate that the cooling intake systems at the Crystal River Power Plant in Florida, a joint nuclear and coal facility, kill about 23 tons of fish and shellfish every year. As a result, top predators such as gulf flounder and stingray have either

97. JEFFREY S. LEVINTON & JOHN R. WALDMAN, THE HUDSON RIVER ESTUARY 198–99 (2006).

98. *Id.*

99. *See* BAUM, *supra* note 4, at 8.

100. *Id.*

101. *Id.*

102. *See Id.* at 4.

103. *Id.*

104. *Id.*

disappeared or changed their feeding patterns.[105] In other parts of Florida, the economic losses induced from four power plants—Big Bend, PL Bartow, FJ Gannon, and Hookers Point—are estimated to be as high as $18.1 million.[106] Similarly, in Southern California, marine biologists and ecologists found that the San Onofre nuclear plant impinged nearly 3.5 million fish in 2003.[107]

A less-noticed, but equally important, impact is that water intake and discharge often alter natural patterns of water levels and flows. Such flows, part of the hydrological cycle, have a natural variability that differs daily, weekly, and seasonally.[108] Plants and animals have adapted to these fluctuations, and such variability is a key component of ecosystem health.[109] Withdrawals and discharges alter this natural variability by withdrawing water during drought conditions or discharging it at different times of the year, with potentially serious (albeit not well-understood) consequences to ecosystem and habitat health.

Oddly, this damage does not always move in a one-way direction. In some cases, the environment has fought back. In September 1984, a flotilla of jellyfish "attacked" the St. Lucie nuclear plant in Florida, forcing both of its reactors to shut down for days due to lack of cooling water.[110]

H. Thermal Pollution and Eutrophication

Thermoelectric power plants also alter the temperatures of lakes, rivers, and streams.[111] The data on temperature intake and discharge points collected by the U.S. Energy Information Administration demonstrates that more than 150 once-through units had summer or winter discharges with water temperature deltas ("[l]arge temperature differences between intake and discharge waters"[112]) greater than 25 degrees Fahrenheit.[113] In

105. *Id.* at 6.
106. *Id.*
107. DAVID LOCHBAUM, UNION OF CONCERNED SCIENTISTS, GOT WATER? 12 (2007).
108. SANDRA POSTEL & BRIAN RICHTER, RIVERS FOR LIFE: MANAGING WATER FOR PEOPLE AND NATURE 9-10 (2003).
109. *See id. at* 9–11.
110. *See* LOCHBAUM, *supra* note 107, at 5.
111. *See* BAUM, *supra* note 4, at 6–9.
112. *Id.* at 6.
113. *Id.* at 7.

some cases, the thermal pollution from centralized power plants can induce eutrophication—a process whereby the warmer temperature alters the chemical composition of the water, resulting in a rapid increase of nutrients such as nitrogen and phosphorous.[114] Rather than improving the ecosystem, such alterations usually promote excessive plant growth and decay, favoring certain weedy species over others, and severely reducing water quality.[115] In riparian environments, the enhanced growth of choking vegetation can collapse entire ecosystems.[116] This form of thermal pollution has been known to decrease the aesthetic and recreational value of rivers, lakes, and estuaries, and to complicate drinking water treatment.[117]

I. Fuel Storage, Boiler Maintenance, and Post-Combustion Wastes

Thermoelectric power plants can degrade water resources in a number of other ways. At coal plants, coal pile runoff forms when water encounters coal storage piles. Coal pile runoff is usually acidic and contains high concentrations of copper, zinc, magnesium, aluminum, chloride, iron, sodium, and sulfate.[118] When plant operators clean coal piles before combustion, the water used for coal cleaning transports pyrites such as suspended solids, sulfates, and metals into the surrounding ecosystem.[119]

During the process of fossil fuel and nuclear electricity generation, impurities also build up over time in the boiler.[120] To maintain quality, water is periodically purged from the boiler and

114. *See* USGS, EUTROPHICATION (2008), http://toxics.usgs.gov/definitions/eutrophication.html (last visited Mar. 13, 2009).

115. *See id.*

116. *See* SEARCA, COMMUNITY-BASED INVENTORY AND ASSESSMENT OF RIVERINE AND RIPARIAN ECOSYSTEMS IN THE NORTHEASTERN PART OF MT. MALINDANG, MISAMIS OCCIDENTAL 15-16 (2005), *available at* http://www.searca.org/brp/pdfs/monographs/River_1st%20gen.pdf.

117. *See* Burak Güneralp & Yaman Barlas, *Dynamic Modeling of a Shallow Freshwater Lake for Ecological and Economic Sustainability*, 167 ECOLOGICAL MODELING 115 (2003), *available at* http://www.sciencedirect.com (use "Quick Search," using title and authors' names; then follow the article's hyperlink).

118. *See* NETL, EMERGING ISSUES, *supra* note 51, at 12–15; CLEAN AIR TASK FORCE ET AL., *supra* note 16, at 5.

119. NETL, EMERGING ISSUES, *supra* note 51, at 12–13; CLEAN AIR TASK FORCE ET AL., *supra* note 16, at 5.

120. *See id.*

replaced with clean water. The purged water, referred to as "boiler blowdown," is often alkaline and contains chemical additives (used for controlling corrosion) as well as trace elements of copper, iron, and nickel that leach from boiler parts.[121]

Plant operators often withdraw and discharge small amounts of water to support the operation of air emissions controls.[122] The combustion waste steam, a mixture of fly ash, bottom ash, boiler slag, and sludge from emissions controls, is typically drenched with water and placed in cooling ponds.[123] Also,

> the country's 600 coal- and oil-fired power plants produce more than one hundred million tons of sludge waste every year. Seventy-six million tons of this waste is primarily disposed on-site at each power plant in unlined wastewater lagoons and landfills that are seldom monitored by the EPA. These wastes are highly toxic, containing concentrated levels of poisons such as arsenic, mercury, and cadmium that can severely damage the human nervous system.[124]

The Arizona Department of Environmental Quality, for example, documented that power stations in Arizona were contaminating ground and surface water with boron, sulfate, chloride, and sediments as a result of disposal of fly and bottom ash in unlined ponds with no leachate collection system to capture contaminants.[125]

In addition to leaking into ground and surface water, lagoons and waste ponds can break and cause devastating spills. In 2000, water containing hundreds of millions of gallons of sludge busted through the bottom of an impoundment system in Kentucky and contaminated dozens of creeks and the Big Sandy River.[126] The sludge decimated local fish populations and buried some homes under seven feet of waste.[127] In 2003, another coal impoundment

121. *See* N.C. DIV. OF POLLUTION PREVENTION AND ENVTL. ASSISTANCE, N.C. DEP'T OF ENV'T AND NATURAL RES., BOILER BLOWDOWN, 1–3 (2004), *available at* http://www.p2pays.org/ref/34/33027.pdf.; *see also* AEP, CORPORATE CITIZENSHIP, *available at* http://www.aep.com/citizenship/crreport/GRI/EN21.aspx.

122. BAUM, *supra* note 4, at 5.

123. Sovacool, *supra* note 62, at 110.

124. *Id.* at 110–111.

125. CLEAN AIR TASK FORCE ET AL., *supra* note 16, at 11.

126. BAUM, *supra* note 4, at 10.

127. *Id.*

in Virginia overflowed and spilled thousands of gallons of liquid coal wastes into surrounding rivers.[128] Following the disposal of coal combustion waste in Pines, Indiana, water from at least 40 residential wells and one business well became contaminated and undrinkable with levels of manganese, arsenic, lead, and boron that far exceeded safe drinking water standards in 2004.[129] Another well near two power plants in Wyoming measured eight times the concentration of boron considered acceptable by the federal government.[130] In late 2008, yet another incident occurred in Tennessee where more than one billion gallons of thick coal ash and sludge containing mercury and arsenic escaped from a Tennessee Valley Authority retention site at their Kingston power plant.[131] The failing waste pond spilled enough toxic coal sludge to fill 1,660 Olympic Size swimming pools into the Clinch River, contaminated 300 acres of land, destroyed 15 homes, and caused more than $1 billion in damages throughout an area bigger area than the Exxon Valdez oil spill.[132] Worryingly, of the 635 coal waste lagoons located nationwide, the Clean Air Task Force estimates that 240 have been constructed in areas atop abandoned underground mines at risk of collapsing.[133]

Wastewater ponds and lagoons that do not leak can still cause serious environmental damage to migrating birds. Scientists have found that "ingesting water with large amounts of dissolved salts can make birds more susceptible to avian botulism" and can "pose chronic effects to aquatic birds."[134]

At reactor sites, even when not generating a single kilowatt hour of electricity, nuclear plants must use water continuously. Nuclear plants "need water to remove the decay heat produced by the reactor core and also to cool equipment and buildings used to

128. *Id.*

129. *Id.* at 11.

130. *Id.*

131. See the Associated Press, "Billions of Gallons of Sludge Could Change Utility: Storage Reviewed After Retention Pond for Coal Waste Burst," December 29, 2008; and Julia A. Seymour, "Tennessee Sludge Spill: Government Disaster 30 Times Worse than Exxon Valdez," Business & Media Institute Press Release, January 14, 2009.

132. *Id.*

133. *Id.*

134. *See* PEDRO RAMIREZ, JR., U.S. FISH & WILDLIFE SERV., TRACE ELEMENT CONCENTRATIONS IN FLUE GAS DESULFURIZATION WASTEWATER FROM THE JIM BRIDGER POWER PLANT, SWEETWATER COUNTY, WYOMING 7 (1992).

provide the core's heat removal."[135] Service water must lubricate oil coolers for the main turbine and chillers for air conditioning, in essence cooling the equipment that in turn cools the reactor.[136] Even when plants are not producing electricity, service water needs can be quite high: 52,000 gallons of water are needed per minute in the summer at the Hope Creek plant in New Jersey; 30,000 gallons per minute for the Milestone Unit 2 in Connecticut; 13,500 gallons per minute for the Pilgrim plant in Massachusetts.[137]

J. Nuclear Accidents and Spills

Electricity generation using nuclear technology also creates wastewater contaminated with radioactive tritium and other toxic substances that can leak into nearby groundwater sources. In December 2005, for example, Exelon Corporation reported to authorities that its Braidwood reactor in Illinois had since 1996 released millions of gallons of tritium-contaminated waste water into the local watershed, prompting the company to distribute bottled water to surrounding communities while local drinking water wells were tested for the pollutant.[138] When caught for its mistake, rather than admit responsibility, Exelon ran a sleek advertising campaign to convince citizens of Illinois that the tritium exposure was "natural" and "can be found in all water sources."[139] The incident led to a lawsuit by the Illinois Attorney General and the State Attorney for Will County who claimed that "Exelon was well aware that tritium increases the risk of cancer, miscarriages, and birth defects, and yet they made a conscious decision to not notify the public of its risk of exposure."[140] Similarly, in New York, a

135. LOCHBAUM, *supra* note 107, at 1.

136. *Id.* at 8.

137. *Id.*

138. *Illinois Sues Exelon for Radioactive Tritium Releases Since 1996*, ENV'T NEWS SERV., Mar. 21, 2006, *available at* http://www.ens-newswire.com/ens/mar2006/2006-03-21-02.asp.

139. The utility noted, "[t]ritium is an isotope of hydrogen that produces a weak level of radiation. It is produced naturally in the upper atmosphere when cosmic rays strike atmospheric gases and is produced in larger quantities as a by-product of the nuclear energy industry. When combined with oxygen, tritium has the same chemical properties as water. Tritium can be found at very low levels in nearly all water sources." Press Release, Exelon Corporation, Update: Tritium Remediation Efforts Progressing Well (March 8, 2007), *available at* http://www.exeloncorp.com/NR/rdonlyres/0796AA69-770A-43E8-A60D-892CFF54EDCD/2978/20070308BraidwoodExelonRemediationUpdate1.pdf.

140. ENV'T NEWS SERV., *supra* note 138.

faulty drain system at Entergy's Indian Point Nuclear Plant on the Hudson River caused thousands of gallons of radioactive waste to be leaked into underground lakes.[141] The Nuclear Regulatory Commission (NRC) accused Entergy of not properly maintaining two spent fuel pools that leaked tritium and strontium-90, cancer-causing radioactive isotopes, into underground watersheds, with as much as fifty gallons of radioactive waste seeping into water sources per day.[142]

K. Indirect Contamination from Air Pollutants and Climate Change

As a final, albeit indirect, impact, conventional electricity generation is by far the largest source of air pollutants that damage water supplies and contribute to global warming. In 2007, American power plants emitted some 9.2 million tons of sulfur dioxide, 4.0 million tons of nitrogen oxides, 44.2 tons of mercury, 125,000 tons of particulate matter, and 2.2 billion tons of carbon dioxide.[143] Such pollution, which in some form is concentrated in almost every region of the country, may affect water supplies in two ways.

First, power plant emissions can completely shut off precipitation from clouds. One study utilized satellite data from space-borne and in situ aircraft and concluded that plumes of reduced cloud particle size and suppression of precipitation occurred near major urban areas and power plants.[144]

Second, power plant emissions contribute directly to climate change, which negatively affects water resources by increasing temperatures, altering precipitation patterns, changing the availability of snowpack, and magnifying the risk of flooding and drought.[145] Warmer temperatures resulting from global warming, for instance, will increase energy demands in urban areas and require more intensive air-conditioning loads, in turn raising the

141. Abby Luby, *Leaks at Indian Point Created Underwater Lakes*, N. COUNTY NEWS, Feb. 28, 2008, *available at* http://www.abbylu.com/pdfs/ENVIRONMENT/indianpointleaks.pdf.

142. *Id.*

143. *See* Benjamin K. Sovacool, *Renewable Energy: Economically Sound, Politically Difficult*, 21(5) ELEC. J. 18, 23 tbl.2 (2008).

144. Daniel Rosenfeld, *Suppression of Rain and Snow by Urban and Industrial Air Pollution*, SCIENCE, Mar. 10, 2000, at 1793.

145. STEPHEN SAUNDERS & MAUREEN MAXWELL, ROCKY MOUNTAIN CLIMATE ORG., LESS SNOW, LESS WATER: CLIMATE DISRUPTION IN THE WEST 1 (2005).

water needs for thermoelectric power generators.[146] Hotter weather also increases the evaporation rates for lakes, rivers, and streams, and thus accelerates the depletion of reservoirs.[147] Hotter weather also causes more intense and longer-lasting droughts as well as more wildfires—which in turn need vast quantities of water to fight and control them.[148]

The National Academies of Science projected (in three of four simulations) that continued climate change will result in winter decreases of available precipitation by fifteen to thirty percent, with reductions of snowpack concentrated in the Central Valley and along the northern Pacific Coast.[149] Climatologists and atmospheric scientists already predict that continued rising temperatures will likely produce substantial reductions in snowpack in the Sierra Nevada Mountains, with significant reductions in Californian stream-flow, water storage, and supply expected.[150] Indeed, snowpack levels have been below average for thirteen of the last sixteen years in the Columbia River Basin, eleven of sixteen years in the Colorado Basin, and fourteen of sixteen years in the Rio Grande.[151] For the nation as a whole, warmer precipitation falling as rain instead of snow will likely reduce snowpack between twenty-six and forty percent by 2049 and between twenty-nine and eighty-nine percent by 2099, resulting in less water available for power plants and other uses.[152] Thus, by emitting carbon into the atmosphere, fossil-fueled power plants slowly but measurably contribute to climate change, rising temperatures, and drought, which in turn threaten to constrain future power production at those very power plants.

II. IDENTIFYING NATIONAL ELECTRICITY-WATER CRISIS AREAS

The water needs associated with thermoelectric fuel cycles and lifecycles therefore make thermoelectric plants a poor choice for

146. *See* BARRY NELSON ET. AL., NATURAL RES. DEF. COUNCIL, IN HOT WATER: WATER MANAGEMENT STRATEGIES TO WEATHER THE EFFECTS OF GLOBAL WARMING 16 (2007).

147. *Id.* at 8.

148. *Id.* at 9.

149. Katharine Hayhoe et al., *Emissions Pathways, Climate Change, and Impacts on California*, 34 PROC. NAT'L ACAD. SCI. 12422, 12424 (2004).

150. *Id.* at 12425.

151. SAUNDERS & MAXWELL, *supra* note 143, at 2.

152. Hayhoe et al., *supra* note 149, at 12423 tbl.1.

generating power in water-constrained locations of the country. Drought and flood are a normal and recurring part of the North American hydrologic cycle.[153] Even though meteorological droughts, identified by a lack of measured precipitation, are difficult to predict and can last months to decades, every part of the country has experienced severe or extreme drought conditions at least once since 1896—with about half of the country suffering drought conditions ten to fifteen percent of the time.[154] In the Pacific Northwest extreme and severe droughts have struck eighty-six times, in California, fifty-three times, and in the Tennessee River Basin, thirty-one times—and this was the part of the nation with the fewest events.[155]

Scientists looking at soil erosion and increased droughts in the past few years have noted that the dustiness has increased dramatically in the past 150 years, of which the 1930s Dust Bowl was one example.[156] Furthermore, saltwater intrusion, due to rises in sea level that many scientists expect as a result of climate change, could cause a reduction of freshwater aquifers on both coasts by an additional forty-five percent more than originally expected.[157] The U.S. Government Accountability Office cautions that water managers in thirty-six states anticipate fresh water shortages under normal conditions in the near future.[158]

Relying on water-intensive electricity generation is thus shortsighted at best (and dangerous at worst) given the future

153. *See* MARK T. ANDERSON & LLOYD H. WOOLSEY, USGS, CIRCULAR NO. 1261, WATER AVAILABILITY FOR THE WESTERN UNITED STATES—KEY SCIENTIFIC CHALLENGES 36–37 (2005), *available at* http://pubs.usgs.gov/circ/2005/circ1261/pdf/C1261.pdf; Peters Lidard, NASA, Floods, Droughts and Water Resources: Hydrology from Space, Presentation at the Smithsonian, Washington, DC 17 (2005), *available at* neptune.gsfc.nasa.gov/ppt/Peters_Lidard_Smithsonian2005.ppt.

154. U.S. DEP'T OF INTERIOR, SPECTER OF INEVITABLE DROUGHT, THE ARID WEST—WHERE WATER IS SCARCE (2006), *available at* http://www.libraryindex.com/pages/2640/Arid-West-Where-Water-Scarce-SPECTER-INEVITABLE-DROUGHT.html; U.S. GEN. ACCOUNTING OFFICE, NO. GAO-03-514, FRESH WATER SUPPLY: STATES' VIEWS OF HOW FEDERAL AGENCIES COULD HELP THEM MEET THE CHALLENGES OF EXPECTED SHORTAGES 16 fig.3 (2003).

155. *Id.*

156. Will Dunham, *Fivefold Dust Increase Chokes the West*, REUTERS, Feb. 24, 2008, http://www.reuters.com/article/environmentNews/idUSN2259224520080224 (last visited Mar. 13, 2009).

157. *Greater Groundwater Loss Due to Rising Sea [sic] Levels*, SCITIZEN, http://www.scitizen.com/screens/blogPage/viewBlog/sw_viewBlog.php?idTheme=13&idContribution=1237 (last visited Mar. 13, 2009).

158. U.S. GEN. ACCOUNTING OFFICE, *supra* note 152, at 5.

likelihood of drought and water shortages. Consequently, we are already seeing signs of the conflict between water and electricity generation throughout the country. The Idaho Department of Water Resources rejected plans from Cogentrix Energy to build an 800-megawatt natural gas plant because of its water needs, and Newport Northwest's proposed 1,300-megawatt natural gas plant was denied on grounds that it would need too much water (17 million gallons a day) from the Spokane-Rathdrum Prairie aquifer.[159] On the Nevada-Arizona border, the Hopi Tribe was unwilling to allow the 1,580-megawatt Mohave Generation Station to pump groundwater beyond 2005 due to the depletion of the Navajo aquifer and the drying up of springs and water sources.[160] The Arizona Corporation Commission rejected a proposed 720-megawatt plant near Wikieup because of water concerns, and only approved a Duke Energy plant under the condition that it purchase surface water to offset every gallon taken from a local aquifer.[161] Similarly, state lawmakers rejected a water permit for the gas-fired 1,800-megawatt Toltec Power Plant near Elroy, Arizona, because of concerns it would consume too much groundwater.[162] In Colorado, the electric utility Aquila had to shut down its 29-megawatt Victoria Avenue Power Plant because of low river levels.[163] In North Carolina, Duke Energy had to run its hydroelectric plants at 40 percent of capacity due to water shortages in the Catawba River Basin.[164] In California, the power producer Calpine tried to circumvent state and federal regulations required for receiving a water permit for their 530-megawatt plant in Palm Desert by signing an agreement with the Fort Mojave Reservation of the Moapa band of Pauite Indians.[165] In Colorado, Xcel energy faced

159. Steve Ernst, *Fate of Idaho Plants May Impact Sumas 2*, PUGET SOUND BUS. J., July 26, 2002, *available at* http://www.bizjournals.com/seattle/stories/2002/07/29/newscolumn2.html.

160. *Lack of Water May Shut Down Power Plant on Arizona-Nevada Border*, U.S. WATER NEWS ONLINE, Nov. 2004, http://www.uswaternews.com/archives/arcsupply/4lackofxx11.html (last visited Mar. 13, 2009).

161. CLEAN AIR TASK FORCE ET AL., *supra* note 16, at 6-7.

162. *Id.* at 7.

163. John Norton, *Water at Pueblo, Colo., Power Plant Slows to Trickle*, PUEBLO CHIEFTAIN, Aug. 29, 2002, at 9.

164. Bruce Henderson, *Duke Power Warns Towns in Charlotte, N.C., Area to Cut Water Use*, CHARLOTTE OBSERVER, Aug. 28, 2002.

165. Mahvish Khan, *Regional Report: California's Needs for Water and Electricity Pit One Against*

barriers to gain approval to construct a 750-megawatt power plant in Pueblo because of the large quantity of water needed to cool the plant—17,000 acre-feet of water, or enough to provide drinking water to 85,000 people.[166]

Given these challenges, and the intensity of the electricity industry's current water needs, what would happen if it expands as planned and predicted? To answer that question, we investigated:

• Rates of population growth per square mile in the contiguous United States from 1995 to 2025 (using data from the U.S. Census Bureau);[167]

• Utility estimates of future planned capacity additions in the contiguous United States by 2025 (using data reported to the U.S. Energy Information Administration);[168]

• Scientific estimates of the anticipated "summer water deficit," which is the difference between water supply and demand during July, August, and September, in inches of water for the contiguous United States in 2025 (using data from the USGS and the NOAA).[169]

We analyzed these trends at the county level and forecasted the percent increase in power plant construction from 2000 to 2025 for all counties within a census division that had any form of power generation. Counties that had no generation at present were not allocated any new generation, and all new generation was assumed to be thermoelectric.

the Other, WALL ST. J., Aug. 1, 2001, at B1.

166. John Norton, *Water, Taxes in Pueblo, Colo., Hamper Xcel Energy Power Plant Expansion*, PUEBLO CHIEFTAIN, Nov. 20, 2003, at 7.

167. Data for population growth at the county level from 1995 to 2025 was collected from the U.S. Census Bureau website, http://www.census.gov/popest/counties/.

168. Data for power plant capacity additions from 2001 through 2006 were collected from the U.S. Energy Information Administration Form EIA-860, *available at* http://www.eia.doe.gov/cneaf/electricity/page/eia860.html.

169. Estimates of the anticipated summer water deficit were taken from Sujoy B. Roy et al., *Water Sustainability in the U.S. and Cooling Water Requirements for Power Generation*, 126 WATER RES. UPDATE 94 (2003) (with immense thanks to Sujoy Roy of the Tetra Tech Corporation). Roy et al. compiled data from the U.S. Geologic Survey and the National Oceanic and Atmospheric Administration. It is important to note that the projections provided by the Roy are merely that—projections. The data they are using from the EIA includes only what utilities told about what power plants they *intend* to construct, not what may actually *get* constructed. Moreover, the projections elucidated by the Roy and the EIA are estimates of technical potential. That is, they do not include the issues surrounding large-scale expansion of transmission and distribution infrastructure for these plants or assessments for how they would affect grid stability, security, or reliability.

Our analysis showed that in 22 metropolitan areas, the water needed to satisfy demands for drinking, agriculture, and other uses will likely tradeoff with the water needed for new power plants. We call these areas "National Electricity-Water Crisis Areas" because they will have a combined population growth of at least 500 people per square mile, electricity demand for at least 2,700 MW of thermoelectric capacity, and a summer water deficit of at least 1.52 inches by 2025. (See Table 3). Ten of these National Electricity-Water Crisis Areas—Atlanta, Charlotte, Chicago, Denver, Houston, Las Vegas, New York, San Francisco, St. Louis, and Washington, DC—plan to add a collective 149,892 MW of thermoelectric capacity by 2025, power stations that would use 29.41 trillion gallons of water per year (or almost 81 billion gallons of water per day). The likely consequences of these power plant additions extend far beyond the electricity industry and include severe increases in water prices, subsidence, water contamination and reduced water quality, and the possibility of billions of dollars in economic damages.

A. Increased Water Prices

The first consequence of rising demand for water will be escalating prices for both water and electricity. As water demand increases while supplies decrease, water prices will escalate, and because of the immense costs of upgrading and building water infrastructure, water prices will rise even higher." For example, the American Water Works Association reports that water charges increased on average seven percent for residential customers from 2004 to 2006 nationwide, due to a combination of constrained supply, infrastructure expenses, and water quality concerns.[170] EPRI calculated in 2002 that the nation would need as much as $239 billion to properly maintain existing water treatment infrastructure.[171] If demand for water continues to grow at current rates, one report estimated the need to invest more than $550 billion,[172] while other federal estimates project $1 trillion could be

170. AM. WATER WORKS ASS'N, 2006 WATER AND WASTEWATER RATE SURVEY (2007).

171. 2 EPRI, WATER & SUSTAINABILITY: AN ASSESSMENT OF WATER DEMAND, SUPPLY, AND QUALITY IN THE U.S.—THE NEXT HALF CENTURY 5.2-5.3(2002) [hereinafter EPRI, WATER & SUSTAINABILITY V.2].

172. *See* SUSTAINABLE WATER RES. ROUNDTABLE, PRELIMINARY REPORT ON WATER

needed between 2000 and 2020.[173]

Table 3: Twenty-Two "National Electricity-Water Crisis Areas"

Rank	County	Total electricity in 2025 (in MW)	Pop. growth 1995 to 2025 (per sq. mile)	Summer water deficit in 2025 (inches)	Metropolitan area
1	Mecklenburg	17,950	1,528	28.72	Charlotte, NC
2	Lake	12,987	1,064	18.10	Chicago, IL
3	Will	27,399	806	16.67	Chicago, IL
4	Queens	11,613	8,056	12.68	New York, NY
5	Cobb	3,480	2,049	9.34	Atlanta, GA
6	Dallas	6,170	1,437	6.60	Dallas, TX
7	Coweta	6,180	510	5.56	Atlanta, GA
8	Denver	4,503	1925	4.98	Denver, CO
9	Montgomery	3,776	757	4.45	Washington, DC and Baltimore, MD
10	St. Charles	3,350	533	4.33	St. Louis, MO
11	Washington	3,203	632	4.20	St. Paul, MN
12	Bexar	9,222	555	2.98	San Antonio, TX

SUSTAINABILITY 36-37 tbl.4.5.1 (2005), *available at* http://acwi.gov/swrr/Rpt_Pubs/prelim_rpt/Chapter_4_SWRRInd.pdf.

173. Douglas Jehl, *As Cities Move to Privatize Water, Atlanta Steps Back*, N.Y. TIMES, February 18, 2003, *available at* http://query.nytimes.com/gst/fullpage.html?res=9D02E1DD113BF933A25751C0A9659C8B63.

13	Calvert	12,938	533	2.92	Washington, DC and Baltimore, MD
14	Harris	4,462	1,179	2.40	Houston, TX
15	Tarrant	2,704	1,170	2.34	Dallas, TX
16	Multnomah	5,402	548	2.24	Portland, OR
17	Contra Costa	4,759	678	1.99	San Francisco, CA
18	Fort Bend	19,656	851	1.88	Houston, TX
19	Wake	5,967	1,266	1.65	Raleigh, NC
20	Suffolk	5,062	1,184	1.65	Boston, MA
21	Clark	20,148	642	1.52	Las Vegas, NV
22	Montgomery	2,871	647	1.52	Houston, TX

While calculating the effect of infrastructural investment on future prices is difficult, if the costs (at the low end of the estimate) are distributed equally over the next seventeen years, the nation will need to spend $46.2 billion each year on water infrastructure, equal to roughly half the existing water industry's annual revenue. More worryingly, after assessing the global water infrastructure needs of 182 countries, another study found that most of these types of cost projections are "routinely and often substantially underestimated, even without accounting for hard-to-measure environmental and social costs."[174] Perhaps because of these trends, one report concluded that "[i]n the business as usual scenario. . . . the cost of supplying water to domestic and industrial users will rise dramatically."[175]

174. Peter H. Gleick, *Water Use*, 28 ANN. REV. ENV'T & RES. 275, 303 (2003).

175. MARK W. ROSEGRANT ET AL., INT'L FOOD POL'Y RESEARCH INST., GLOBAL WATER OUTLOOK TO 2025: AVERTING AN IMPENDING CRISIS 4-5 (2002).

B. Subsidence and Deterioration of Water Quality

Rising electricity and water prices tell only part of the story. By using large amounts of water, power plants alter the flow of surface water and in some cases directly consume groundwater. Such intensive water practices alter the naturally balanced hydrological cycle by depleting water sources faster than they normally replenish. Ironically, the more water supplies are depleted, the more electricity is needed to help supply and convey water. Already, about three percent of the nation's electricity goes merely toward moving water.[176] The most energy-intensive portion of water delivery is pumping, which varies with water depth: 540 kWh per million gallons from a depth of 120 feet, but as much as 2,000 kWh per million gallons at depth of 400 feet.[177] In California, the state consumes seven percent of its electricity just for pumping water (the amount of electricity required to transport water to Southern California is so significant because the water must be transported more than 1,000 kilometers via canal and pumped over the Tehachapi Mountains, a vertical lift of 610 meters).[178] Greater use of thermoelectric power plants thus depletes available water, and then requires more electricity to pump water to existing plants, creating a feedback loop that worsens the problem.

In addition to creating a need to draw water from deeper and more distant places, sustained water pumping induces subsidence, the gradual settling or sudden sinking of the earth's surface.[179] In the Southwest, subsidence often occurs as deep fissures and cracks, while in the East it appears as sinkholes.[180] More than eighty percent of subsidence in the U.S. is related to the withdrawal or pumping of groundwater.[181] Subsidence significantly damages buildings, wells, highways, and water systems, as well as the operation of flood reservoirs and drainage facilities.[182] If

176. 4 EPRI, TOPICAL REPORT 1006787, 2002, WATER & SUSTAINABILITY: U.S. ELECTRICITY CONSUMPTION FOR WATER SUPPLY & TREATMENT—THE NEXT HALF CENTURY 20 [hereinafter EPRI, WATER & SUSTAINABILITY V.4].

177. DOE, ENERGY DEMANDS, *supra* note 4, at 25.

178. *See* JAMES A. MCMAHON ET AL., LAWRENCE BERKELEY NAT'L LAB. WHITE PAPER, SAVING WATER SAVES ENERGY 5 (2003).

179. ANDERSON & WOOLSEY, *supra* note 151, at 39.

180. U.S. GEN. ACCOUNTING OFFICE, *supra* note 152, at 54.

181. *Id.*

182. *Id.*

subsidence occurs over aquifers, it can compact the land and reduce permanent storage capacity by thirty percent.[183] In some parts of Arizona, for example, water level declines have exceeded 300 feet and resulted in subsidence greater than 10 feet.[184] When subsidence occurs near coastal aquifers, saltwater can migrate inland to completely contaminate water supplies.[185]

C. Economic Stagnation and Billions of Dollars in Damages

In the long-term, since all industries depend on water and electricity, water shortages and water prices could increase the price of almost everything. In the agricultural sector, irrigation systems rely on electricity to convey water. For instance, three-fourths of irrigation systems in Colorado are electrical.[186] Rising water prices could place great stress on cropland, livestock, and food production. Researchers at the University of Georgia calculated that for every $1 million decline in agricultural production, there is a resulting additional $700,000 decline in other sectors of the economy.[187] The Susquehanna River Basin Commission reported that a drought in 1999 cost 34 counties in New York State $2.5 billion in agricultural losses, while some Pennsylvanian farmers lost as much as 70 to 100 percent of their crops at a statewide expense of $500 million.[188] In 2003, the federal government spent $3.1 billion to offset water shortage-induced agricultural losses.[189]

In the health sector, degraded water quality and water shortages acutely affect chemotherapy patients, those living with HIV/AIDS, transplant patients, children and infants, the elderly, and pregnant women and their fetuses, in addition to others with special health needs.[190]

In the aquaculture and fisheries industry, at least 30,000 fish died near Klamath, Oregon, in 2002 when water shortages forced

183. *Id.*

184. ARIZ. GEOLOGICAL SURVEY, CONTRIBUTED REPORT CR-07-C, LAND SUBSIDENCE AND EARTH FISSURES IN ARIZONA 3 (2007).

185. ANDERSON & WOOLSEY, *supra* note 151, at 59.

186. DOE, WIND/WATER NEXUS, *supra* note 23, at 2.

187. U.S. GEN. ACCOUNTING OFFICE, *supra* note 152, at 69.

188. *Id.* at 68.

189. *Id.* at 67.

190. U.S. ENVTL. PROT. AGENCY, WATER ON TAP: WHAT YOU NEED TO KNOW 1 (2003).

thousands of farmers to form a "bucket brigade" by standing shoulder to shoulder to pass water from the Link River to local canals.[191] The Washington State Department of Ecology estimates that the 2001 water shortage cost them as much as $400 million in damages and the loss of up to 7,500 jobs.[192]

In the transportation sector, water shortages could reduce the water levels of rivers and lakes, thereby making inland navigation impossible and forcing operators to switch to more expensive (and polluting) modes of transportation such as truck or rail. Inland waterways carry approximately fifteen percent of the nation's freight (or 620 million tons of cargo) by volume or the equivalent of 24 million trucks.[193] Yet inland waterway navigation requires functioning dams, locks, and river channels. When channel depth decreases, most vessels can no longer utilize these waterways without the construction of special locks or dredging, both environmentally destructive activities.[194]

In the forestry and recreation sectors, water shortages can increase the risk of fire hazards and mortality rates for wildlife. Diminished water flows into the Florida Everglades, for instance, have resulted in both reduced habitat for wildlife populations and a 90 percent reduction in the population of wading birds.[195]

In light of the numerous examples discussed above, it is clear that the costs of water shortages have reached billions of dollars. From June–September 1980, water shortages in the Central and Eastern U.S. cost the country $20 billion.[196] In the summer of 1988, droughts in the U.S. resulted in an estimated $6 to $9 billion in losses in certain areas' agricultural and ranching sectors, and cost the country $40 billion in damages to the economies of the Eastern and Central parts of the country.[197] Indeed, the National Oceanic and Atmospheric Administration identified eight water shortages from drought or heat waves in the twenty years preceding the 2000

191. U.S. GEN. ACCOUNTING OFFICE, *supra* note 152, at 72–74.

192. *Id.* at 68.

193. T. Randall Curlee & Michael J. Sale, *Water and Energy Security*, UNIVS. COUNCIL ON WATER RES. 7–8, July 31, 2003, http://www.ucowr.siu.edu/proceedings/2003%20Proceedings/ T18C.pdf.

194. *Id.*

195. U.S. GEN. ACCOUNTING OFFICE, *supra* note 152, at 6.

196. *Id.* at 68.

197. *Id.* at 67–68.

report that "each resulted in $1 billion or more in monetary losses."[198] The implication is that continued water shortages brought about by or exacerbated by new thermoelectric power plants could similarly induce billions of dollars of damages.

III. THE INADEQUACY OF CURRENT APPROACHES

Despite the seriousness of possible future water shortages, electric utility companies in the United States have mostly ignored water concerns and continue to propose new, water-intensive nuclear and fossil-fueled plants as the best way to produce new forms of electricity.[199] "Until recently, water use and consumption have not been significant factors in decisions related to the permitting and siting of power plants."[200] Those within the electricity industry continually downplay the importance of water management techniques for minimizing thermoelectric water consumption,[201] and those in water management tend to focus exclusively on securing access to greater supplies of water, privatization, and changes in water pricing, but rarely rely on energy policy tools.[202] As we will see below, the problem is further enhanced by inadequate state, federal, and private approaches to electricity and water management.

A. Inadequate Organizational Focus and Funding

Rather than pursue a synergistic approach to water and energy problems, the National Research Council warned that government organizations lack any sort of coordinated or effective approach to them.[203] The researchers cautioned that water management does not fall logically or easily within the purview of a single federal agency, and that lack of interagency cooperation prevents helpful

198. *Id.* at 67 (emphasis added).

199. S. Alliance for Clean Energy, *supra* note 37, at 1.

200. CLEAN AIR TASK FORCE ET AL., *supra* note 16, at 6.

201. *See generally* EPRI, WATER & SUSTAINABILITY V.1, *supra* note 11 (discussing options of reducing water use but failing to mention any water management techniques).

202. *See generally* BOBERG, *supra* note 40 (discussing a number of water management tools such as privatization and changes in price but failing to mention techniques relating to electricity generation).

203. COMM. ON ASSESSMENT OF WATER RES. RESEARCH, NAT'L RESEARCH COUNCIL, CONFRONTING THE NATION'S WATER PROBLEMS: THE ROLE OF RESEARCH 56 (2004).

collaboration.[204] Water resource and water research funding have not paralleled growth in demographic and economic parameters such as population, Gross Domestic Product (GDP), or budget outlays.[205] The population of the U.S. increased twenty-six percent between 1973 and 2003, GDP and federal budget outlays have doubled, but funding for water management resources has remained stagnant.[206] Per capita spending on water resources research has fallen from $3.33 in 1973 to $2.40 in 2001 (in 2001 dollars).[207]

Similar problems exist with the federal government's approach to energy and electricity policy.

> The complicated nature of managing the nation's nuclear stockpile, cleaning up environmentally hazardous waste, and conducting basic and energy research, have made programs within the DOE difficult to integrate. The convoluted and labyrinthine organizational structure of the DOE makes it especially challenging to coordinate its vast network of field offices and national laboratories. Multiple levels of reporting exist in each institution between management, group leaders, and research associates, and externally between the DOE, other laboratories, operations offices, and headquarters program offices.[208]

The U.S. General Accounting Office and the Committee for Economic Development have both warned that unclear chains of command, weak integration of programs and functions, and confusion over staff roles remain common.[209]

Neither the government nor private sector provides enough money for energy R&D. From 1985 to 1994, the federal

204. *Id.* at 2.
205. *Id.* at 9.
206. *Id.*
207. *Id.*
208. Benjamin K. Sovacool, *Replacing Tedium with Transformation: Why the U.S. Department of Energy Needs to Change the Way it Conducts Long-term R&D*, 36 ENERGY POL'Y 923, 923-928 (2008) [hereinafter Sovacool, *Replacing Tedium*]; *see also* Benjamin K. Sovacool, *Innovating the Innovators: The Case for Transformational Energy Research and Development,* 6 INT'L J. ENERGY TECH. POL'Y 368, 368-380 (2008) [hereinafter Sovacool, *Innovating the Innovators*].
209. U.S. GEN. ACCOUNTING OFFICE, NO. GAO-02-51, DEPARTMENT OF ENERGY: FUNDAMENTAL REASSESSMENT NEEDED TO ADDRESS MAJOR MISSION, STRUCTURE, AND ACCOUNTABILITY PROBLEMS 5 (2001); COMM. ON ECON. DEV., AMERICA'S BASIC RESEARCH: PROSPERITY THROUGH DISCOVERY 2 (1998).

government invested only approximately three percent of its total R&D expenditures on energy related technologies, even though energy industries contributed more than eight percent to the country's Gross Domestic Product.[210] The budget for the DOE to conduct research and development of renewable, fossil, and nuclear generating technologies declined by more than eighty-five percent (in real terms) between 1978 and 2005, dropping from $5.5 billion to $793 million.[211]

Recent events in the energy sector make it unlikely that private industry will compensate for public underinvestment. The restructuring of the electric utility industry and the repeal of the Public Utilities Holding Company Act of 1935 (PUHCA) have increased the incentive for companies and firms to invest in short-term technologies with rapid rates of payback.[212] Utilities are more likely to make investments only in short-term projects that have better discount rates, lower risk, and better perceived quarterly returns for investors.[213] The financial consolidation of utilities creates strong incentives for managers "to shift the focus of their R&D from collaborative projects benefiting society to proprietary R&D giving their affiliates a competitive edge."[214]

B. Inadequate Data Collection

Current energy and water regulations, along with government data collection, are clearly inadequate. Section 979 of the Energy Policy Act of 2005 mentions the importance of water and energy, but provides no funding for R&D activity and merely recommends that the DOE release a report on the matter.[215] Sections 316(a) and 316(b) of the Clean Water Act regulate the discharge of cooling water and power plant intake procedures.[216]

210. R.N. Schock et al., *How Much is Energy Research & Development Worth as Insurance?*, 24 ANN. REV. ENERGY & ENV'T 487, 488 (1999).

211. U.S. GOV'T ACCOUNTABILITY OFFICE, NO. GAO-07-106, DEPARTMENT OF ENERGY: KEY CHALLENGES REMAIN FOR DEVELOPING AND DEPLOYING ADVANCED ENERGY TECHNOLOGIES TO MEET FUTURE NEEDS 5 (2006).

212. Benjamin K. Sovacool, *PUHCA Repeal: Higher Prices, Less R&D, and More Market Abuses?*, 19 ELECTRICITY J. 85, 85–89 (2006).

213. *Id.*

214. *Id.* at 87.

215. 42 U.S.C. § 15801 (2005).

216. 33 U.S.C. § 1326 (2005).

However, as Part I of this article shows, many violations are not enforced. The U.S. Energy Information Administration (EIA) used to compile a national database of thermoelectric plants and their water use, using information collected through "Form EIA-767," but terminated the process in 2005 due to budgetary constraints.[217] The EIA's replacement "Form EIA-860" has only incomplete data on power plant water use. For numerous plants, the form either fails to list the water source or lists a general term such as "aquifer" or "municipal utility" without specifying which aquifer or utility.[218] The newest "Form EIA-923," was just released in mid-2008, so the EIA is still in the process of collecting data.[219] Data from the USGS on national water use is eight years old, and its process of collecting and compiling data for the next report is already four years behind schedule.[220]

C. Inadequate R&D Programs

Through separate programs at the National Energy Technology Laboratory (NETL) and Sandia National Laboratory, the DOE has begun to look into making conventional power plants more water-efficient.[221] Neither program, however, focuses on the use of wind, solar, and energy efficiency to displace water use, and both appear unlikely to bring new technologies to commercialization anytime soon. NETL, for instance, has initiated a research and development program on how to reduce water use at conventional power plants.[222] The program, while certainly innovative, aims to have new technology commercially available by 2020, not nearly

217. ARTHUR N. MARIN, PROPOSED CHANGES TO POWER GENERATOR DATA COLLECTION ACTIVITIES AND FORM EIA-767 2 (2007), *available at* www.nescaum.org/documents/nescaum-comments_eia-forms-2007-may30-final.pdf/.

218. U.S. ENERGY INFO. ADMIN., FORM EIA-860 DATABASE ANNUAL ELECTRIC GENERATOR REPORT (2008), http://www.eia.doe.gov/cneaf/electricity/page/eia860.html.

219. *See* U.S. ENERGY INFO. ADMIN., THE NEW FORM EIA-923 (2008), http://www.eia.doe.gov/cneaf/electricity/2008forms/consolidate_923.html.

220. USGS, WATER USE IN THE UNITED STATES (2008), http://water.usgs.gov/watuse/ (last visited Mar. 13, 2009).

221. *See* NETL, The Energy Lab, Water-Energy Interface, http://www.netl.doe.gov/technologies/coalpower/ewr/water/index.html (last visited Mar. 13, 2009); Sandia National Laboratories, Water Initiative, http://www.sandia.gov/water/ (last visited Mar. 13, 2009).

222. THOMAS J. FEELEY & BARBARA CARNEY, NETL, INNOVATIVE APPROACHES AND TECHNOLOGIES FOR IMPROVED POWER PLANT WATER MANAGEMENT 2 (2005), *available at* http://www.netl.doe.gov/publications/factsheets/program/Prog055.pdf.

soon enough to avoid crises by 2025.[223] Furthermore, each of the options being promoted by the DOE—alternative cooling systems, using untraditional sources of water, enabling power plants to produce some of their own water, and clean coal technologies—face unique constraints.

1. Alternative Cooling Systems

Alternative cooling systems, such as wet and dry cooling, are less efficient and more costly than once-through cooling. Wet cooling towers need less water but require pretreatment and have higher costs.[224] Dry-cooling, an approach that replaces evaporative cooling towers in closed-loop systems with cooling towers dependent entirely on air, is ineffective in dry and arid climates.[225] Direct-acting dry-cooling, the most common dry-cooling technique in the United States, works like an automobile radiator with the steam in the tube cooled by air blown over the outside.[226] Since dry-cooling systems can approach only the ambient air temperature, they are best suited to wet, cool climates.[227] "As the cooling system outlet temperature increases, plant efficiency decreases."[228] Thus, "[o]ver the course of a year, the output of a plant with dry cooling will be about 2 percent less than that of a similar plant with evaporative closed-loop cooling," and "plant efficiency may decrease by up to 25 percent" in extremely hot weather.[229]

Only a very small number of plants rely on dry cooling, since they lower plant efficiency and have the highest costs. Dry-cooling systems also have significant negative impacts on the operation of pumps, fans, and equipment.[230] Retrofit applications are problematic due to increased stress on turbines and generators, increased air emissions, and the larger environmental footprints needed for construction and operation.[231]

Newer technologies, such as using ice or high thermal

223. Feeley, *supra* note 3, at 15.
224. ZAMMIT & DIFILIPPO, *supra* note 34, at 2, 5, 14–28.
225. DOE, ENERGY DEMANDS, *supra* note 4, at 37.
226. BAUM, *supra* note 4, at 3.
227. DOE, ENERGY DEMANDS, *supra* note 4, at 37.
228. *Id.*
229. *Id.*
230. *Id.*
231. FEELEY & CARNEY, *supra* note 222, at 3.

conductivity foam to cool power plants, are currently not economically feasible.[232] As researchers from Siemens concluded, "it will take several years of development and continued focus on water resource management before systems such as this yield the level of return that will warrant their common use."[233]

2. Untraditional Sources of Water

Researchers have also investigated treating and reusing "impaired," "nonpotable," "produced," "brackish," "reclaimed," or "gray" water to cool power plants. The most common applications include using secondary treated municipal waste water, passively treated coal mine drainage, and ash pond effluent.

The biggest challenge is cost. Systems utilizing mine water have extra capital costs as high as $5.7 million and operating costs as high as $1.4 million, resulting in an annualized cost of an additional 79 cents per every 1,000 gallons of water reused.[234] Two prototype systems in West Virginia had operating costs 119 and 193 percent higher than expected.[235]

Systems using other types of reclaimed water require secondary treatment, filtration, and disinfection to prevent corrosion, biological growth, fouling, and foaming. At the fifty-seven power plants currently using reclaimed water, for instance, contaminants cause a variety of problems including mineral scaling from calcium phosphate, stress cracking of metal heat transfer surfaces, and excessive biological growth on material surfaces.[236] The use of reclaimed water at the 4-unit 1,800 MW coal-fired San Juan

232. NETL, IEP WATER-ENERGY INTERFACE ADVANCED COOLING TECHNOLOGY (2008), http://204.154.137.14/technologies/coalpower/ewr/water/adv-cooling.html.

233. JOHN H. COPEN ET AL., PRINCIPLES OF FLUE GAS WATER RECOVERY SYSTEM 10 (2005), http://www.powergeneration.siemens.com/NR/rdonlyres/CAFF9B34-1393-48E9-9BBA-CB60D3F4815A/0/5_Principles_of_Flue_Gas.pdf.

234. THOMAS J. FEELEY & LYNN BRICKETT, NETL, STRATEGIES FOR COOLING ELECTRIC GENERATING FACILITIES UTILIZING MINE WATER: TECHNICAL AND ECONOMIC FEASIBILITY 2 (2005), *available at* http://www.netl.doe.gov/publications/factsheets/project/Proj363.pdf.

235. NETL, POWER PLANT WATER MANAGEMENT: STRATEGIES FOR COOLING ELECTRIC GENERATING FACILITIES UTILIZING MINE WATER: TECHNICAL AND ECONOMIC FEASIBILITY—WEST VIRGINIA UNIVERSITY (2008), http://www.netl.doe.gov/technologies/coalpower/ewr/water/pp-mgmt/wvu.html.

236. J.A. VEIL, ARGONNE NAT'L LAB., PUBL'N NO. ANL/EVS/R-07/3, USE OF RECLAIMED WATER FOR POWER PLANT COOLING 17 (2007), *available at* http://www.ead.anl.gov/pub/doc/ANL-EVS-R07-3_reclaimedwater.pdf.

Generating Station in New Mexico validated these concerns. Researchers tested wet surface air cooling utilizing degraded water on one of the units for 147 days, and found that a number of unexplained process leaks occurred and that contaminants from the reused water interfered with the unit's ability to properly operate.[237]

Feasibility studies looking at expanding the pilot project at San Juan to all four generating units found that it would necessitate collection and gathering of wastewater from a three-city area, the construction of a collection center, and the completion of an entirely new 28.5-mile pipeline to send the water from the collection center to the power plant.[238] A follow-up economic analysis found that this would cost an extra $4.52 to $13.64 for every thousand gallons of water.[239] Such a project, totaling an estimated $43.1 million, would only be profitable if water rates for the San Juan plant rose from $6.50 to $47 per acre feet. And, in the end, even if this project was completed, it would supply just 8.8 to 10 percent of the plant's water needs.[240]

Since the production of reclaimed water is concentrated in Alaska, California, Kansas, Louisiana, Oklahoma, Texas, and Wyoming (accounting for 90.1 percent of produced water), it would be prohibitively costly for forty-three states. Of the produced water in these seven states, only thirty-seven percent is of the quality needed to run in power plants[241] and would still need to be treated using high-efficiency reverse osmosis and brine concentration

237. ROBERT GOLDSTEIN & KENT ZAMMIT, EPRI, TECHNICAL PROGRESS REPORT: USE OF PRODUCED WATER IN RECIRCULATING COOLING SYSTEMS AT POWER GENERATION FACILITIES: DELIVERABLE NUMBER 12 26 (Jun. 2006).

238. KENT ZAMMIT & MICHAEL N. DIFILIPPO, EPRI, SEMI-ANNUAL TECHNICAL PROGRESS REPORT: USE OF PRODUCED WATER IN RECIRCULATING COOLING SYSTEMS AT POWER GENERATION FACILITIES: DELIVERABLE NUMBER 2 INFRASTRUCTURE AVAILABILITY AND TRANSPORTATION ANALYSIS ES-1 (Aug. 2004).

239. KENT ZAMMIT & MICHAEL N. DIFILIPPO, EPRI, SEMI-ANNUAL TECHNICAL PROGRESS REPORT: USE OF PRODUCED WATER IN RECIRCULATING COOLING SYSTEMS AT POWER GENERATION FACILITIES: DELIVERABLE NUMBER 3 TREATMENT AND DISPOSAL ANALYSIS: DELIVERABLE NUMBER 3 35 (Oct. 2004).

240. ZAMMIT & DIFILIPPO, *supra* note 34, at ES-1.

241. The EPRI reports that produced waters with more than 30,000 mg/l TDS are "very costly" and thus excluded from analysis. *See* KENT ZAMMIT & MICHAEL N. DIFILIPPO, EPRI, SEMI-ANNUAL TECHNICAL PROGRESS REPORT: USE OF PRODUCED WATER IN RECIRCULATING COOLING SYSTEMS AT POWER GENERATION FACILITIES: DELIVERABLE NUMBER 8 APPLICABILITY TO OTHER REGIONS IN THE US 1 (Jan. 2005).

technologies, which are expensive.[242]

3. Power Plant Water Production

Another option being explored is enabling power plants to produce some of their own water, either through capturing water vapor from flue gas or using the thermal discharges from power plants to desalinate water.

Water is naturally present in all deposits of coal, constituting as much as sixty percent of its weight. The coal combustion process thus releases water vapor that can be recovered from flue gas using liquid desiccant-based absorption systems or modified electrostatic precipitators.[243] These technologies, however, are not yet able to handle the large volumetric flow rates found at power plants. It is not known how water capture would interact with power plant emissions controls for mercury, sulfur dioxides, and nitrogen oxides.[244] No commercially available technology exists, systems would require massive and expensive equipment, they would likely be limited to high ambient temperature, and would almost certainly result in decreased power plant performance.[245] Even if the capture technologies were perfected, researchers expect that such innovations would reduce only five percent of evaporative water loss at power plants.[246]

Diffusion-driven desalination, a process that uses the excess waste heat from power plants to produce distilled water, faces similar barriers.[247] Its application would be limited to power-producing facilities situated along ocean coastlines, immediately ruling out

242. *Id.* at 6.

243. *See* Jeff Hoffmann, Tom Feeley & Barbara Carney, DOE/NETL's Power Plant Water Management R&D Program—Responding to Emerging Issues, Presentation at the 8th Electric Utilities Environmental Conference 3 (Jan. 24-26, 2005), *available at* http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/05_EUEC_Hoffmann_1.pdf; THOMAS J. FEELEY & SARA M. PLETCHER, NETL, REDUCTION OF WATER USE IN WET FGD SYSTEMS 2 (2006), *available at* http://www.netl.doe.gov/publications/factsheets/project/Proj432.pdf.

244. *Id.*

245. NETL, POWER PLANT WATER MANAGEMENT: WATER EXTRACTION FROM COAL-FIRED POWER PLANT FLUE GAS-ENERGY & ENVIRONMENTAL RESEARCH CENTER (2008), *available at* http://www.netl.doe.gov/technologies/coalpower/ewr/water/pp-mgmt/eerc.html.

246. FEELEY & PLETCHER, *supra* note 241, at 2.

247. JAMES F. KLAUSNER & RENWEI MEI, INNOVATIVE FRESH WATER PRODUCTION PROCESS FOR FOSSIL FUEL PLANTS: ANNUAL REPORT I (2005) (for a general introduction), *available at* http://www.osti.gov/bridge/servlets/purl/862097-NCi5jG/.

the bulk of power plants.[248] Optimal operating conditions require hot climates, excluding coastal power plants in the Pacific Northwest and Northeast. It is also expensive, costing as much as ninety-seven cents for every cubic meter of water,[249] and plants would still risk impingement and entrainment of marine biodiversity (discussed in section 1.6).

4. Clean Coal Alternatives

Clean coal technologies have additional water needs in excess of the water use associated with conventional units. Almost all clean coal technologies rely on a multi-step process of capturing, storing, transporting, and sequestering CO_2.[250] The "capture" stage requires separating CO_2 from emissions and exhaust into pure waste streams, then pressurizing it for transport.[251] While effective at preventing carbon from escaping directly into the atmosphere, capturing creates serious tradeoffs in operating efficiency. The easiest way to capture CO_2 is to "scrub" it from the flue or exhaust gas using a chemical like amine to extract the greenhouse gas.[252] "But this process typically entails a 30 percent energy penalty (meaning it consumes one-third of the plant's output) . . . [a]lternatively, power plants can operate on pure oxygen rather than air, but doing so requires a 24 to 40 percent energy penalty."[253] These energy penalties mean that clean coal plants use more fuel and water to produce each unit of electricity.

Most clean coal systems are coupled with carbon capture and storage technologies that attempt to deposit carbon in underground aquifers and carbon sinks.[254] Each of these storage methods, however, has its own additional risks and water needs.

Currently, three types of carbon capture and storage techniques exist. Biological sequestration enhances natural carbon sinks that

248. *Id.*

249. *Id.* at 35.

250. JEFFREY LOGAN ET AL., WRI ISSUE BRIEF NO. 1, OPPORTUNITIES AND CHALLENGES FOR CARBON CAPTURE AND SEQUESTRATION 2 (2007), *available at* http://pdf.wri.org/opportunities-challenges-carbon-capture-sequestration.pdf.

251. *Id.* at 2.

252. SOVACOOL, *supra* note 44, at 22.

253. *Id.*

254. NETL, EMERGING ISSUES, *supra* note 51, at 42-49.

store greenhouse gases, such as vegetation and some soils.[255] Geologic storage, where carbon is captured from a stationary source (such as a power plant) and stored underground in geologic formations, is often combined with advanced oil recovery or coal-bed methane operation in what is known as "value added sequestration."[256] Carbon sequestration utilizes new sorbents and processes to capture CO_2 at its combustion source. Identifying sites that meet the needed permanence, cost, and safety requirements is an enormously complicated issue, and considerable underground testing must occur before injection begins.[257]

The environmental and liability issues associated with sequestration are daunting. Groundwater contamination can occur if stored CO_2 leaks or unexpectedly migrates.[258] CO_2 injection can result in pressure build-up and an increase in seismic activity.[259] Operational leakage to the surface can create public health risks since high concentrations of CO_2 can induce fatal asphyxia.[260] Slow, sudden, or chronic releases of CO_2 can occur at the surface, accelerating climate change.[261] Sequestration can contaminate underground assets such as brines and natural gas fields, exacting significant property damage.[262] Environmental degradation can occur as sequestered CO_2 leaks to the surface and impacts vegetation, trees, and soil composition.[263]

Biological sequestration systems have environmental risks as well. The DOE estimates that biological sequestration plantations can decrease stream-flows by fifty-two percent.[264] Geologic storage systems face three water-related challenges: storing carbon dioxide in geologic formations often displaces significant volumes of water; value added sequestration tends to produce significant amounts of brackish water; and plumes of injected carbon dioxide often

255. *Id. at* 45–48.
256. *Id.* at 47.
257. *Id.*
258. Logan, *supra* note 253, at 4 (*citing* Mark A. de Figueiredo, The Liability of Carbon Dioxide Storage (Feb. 2007) (unpublished Ph.D. dissertation, MIT University), *available at* http://sequestration.mit.edu/pdf/Mark_de_Figueiredo_PhD_Dissertation.pdf).
259. *Id.*
260. *Id.*
261. *Id.*
262. *Id.*
263. *Id.*
264. NETL, EMERGING ISSUES, *supra* note 51, at 45.

migrate over time, threatening the stability of underground aquifers and groundwater sources.[265]

IV. THE CASE FOR EXECUTIVE ACTION

The future, therefore, looks bleak. Water-intensive power plants will continue to use and pollute water, placing an extraordinary amount of stress on the existing water system, driving water prices up, and risking potentially widespread and serious economic impacts. Luckily, this dry future can be averted by rapidly deploying three types of clean power technologies. As this section shows, energy efficiency and demand-side management programs and practices, wind turbines, and solar photovoltaic (PV) panels obviate the need for water-intensive fuel production including mining and transportation. They also displace the need to combust fuel and the associated cooling, thermal pollution, and emissions with fossil fuel and nuclear power generation.

A. Clean Power to the Rescue

Researchers at the Virginia Polytechnic Institute & State University in Blacksburg, VA, recently estimated that 3,000 to 6,000 gallons of water are required to burn one 60-watt incandescent light bulb for twelve hours a day over the course of one year. By contrast, using a compact fluorescent bulb for the same amount of time saves about 2,000 to 4,000 gallons of water per year.[266]

In a 2006 report, the DOE acknowledged wind power and solar photovoltaics could play a key role in averting a "business-as-usual scenario" where "consumption of water in the electric sector could grow substantially."[267] Another recent DOE report noted that "greater additions of wind to offset fossil, hydropower, and nuclear assets in a generation portfolio will result in a technology that uses no water, offsetting water-dependent technologies."[268] And Ed Brown, director of Environmental Programs at the University of

265. *Id.* at 47.

266. Ana Constantinescu, *Study Examines Amount of Water Needed to Produce Various Types of Energy*, VIRGINIA TECH NEWS, Apr. 22, 2008, http://www.vtnews.vt.edu/story.php?relyear=2008&itemno=260.

267. DOE, ENERGY DEMANDS, *supra* note 4, at 10.

268. DOE, WIND/WATER NEXUS, *supra* note 23, at 2.

Northern Iowa, concluded that "billions of gallons of water can be saved every day" through the greater use of renewable energy technologies.[269] The DOE has confirmed that every 4,000 MW of wind turbines in the Interior West displace the need to withdraw about 10.51 billion gallons of water and consume 6.31 billion gallons of water every year.[270]

The American Wind Energy Association conducted one of the most comprehensive assessments of renewable energy and water consumption. Looking purely at water consumption and not withdrawal, its study estimated that wind power uses less than 1/600 as much water per unit of electricity produced as does nuclear, 1/500 as much as coal, and 1/250 as much as natural gas (small amounts of water are used to clean wind and solar systems).[271]

The Southern Alliance for Clean Energy conducted a similar analysis in the Southeast and found that nuclear plants consume about 620 times the water a comparable amount of electricity produced by a wind farm would require, and that coal plants consume 490 times more water than wind energy.[272] In short, the use of wind, solar PV, and energy efficiency conserves substantial amounts of water that would otherwise be withdrawn and consumed for the production of electricity.

Consider the case of Colorado, where Xcel Energy was forced to close its 505 MW power plant in Brush, Colorado, because it relied on two billion gallons of water each year from the South Platte River.[273] Utilities in the region had to immediately consider abandoning their plants to install 39,000 MW of new thermoelectric generation that would have increased overall water demand by 116 million gallons of water per day (an increase of 20 percent).[274] Instead, they found that every 1,800 MW of wind

269. Ed Brown, *Renewable Energy Brings Water to the World*, RENEWABLE ENERGY WORLD, Aug. 23, 2005, http://www.renewableenergyaccess.com/rea/news/story?id=35664.

270. DOE, WIND/WATER NEXUS, *supra* note 23, at 2 tbl.2.

271. AMERICAN WIND ENERGY ASSOCIATION, WIND WEB TUTORIAL, http://www.awea.org/faq/wwt_environment.html (follow "How much water do wind turbines use compared with conventional power plants?" hyperlink) (last visited Mar. 13, 2009).

272. S. Alliance for Clean Energy, *supra* note 37, at 2–3.

273. April Reese, *Western Power Plants Come Under Scrutiny as Demand and Drought Besiege Supplies,* LAND LETTER, Mar. 4, 2004, *available at* http://www.eenews.net/Landletter/2004/03/04/archive/1?terms=reese (log-in required).

274. *Id.*

energy capacity saved 6.8 million gallons of water per year.[275] The lesson is simple, indicated Matt Baker of Environment Colorado: "The more we use renewables, the more we can conserve water."[276]

B. Proposal for a "National Electricity-Water Crisis Areas" Executive Order

To address the concerns raised in the previous three sections, we believe that the President of the United States should pass an Executive Order designating select regions of the country "National Electricity-Water Crisis Areas" and creating a National Electricity Water Policy Program Office at the Federal Energy Regulatory Commission (Proposed language for this Executive Order is offered in Appendix 1).

The Executive Order could place a selective but immediate moratorium on thermoelectric power plants. Federal relicensing and approval of thermoelectric capacity upgrades or additions in identified National Electricity-Water Crisis Areas could be prohibited. The Executive Order could also authorize the Federal Energy Regulatory Commission (FERC) to implement a "National Electricity Water Policy Surcharge" of 0.001¢/kWh levied on every unit of wholesale electricity generated in the U.S.[277] The surcharge would be very similar to other surcharges FERC has levied in the past relating to third party transshipment of natural gas,[278] natural

275. *Id.*

276. *Id.*

277. There are at least three justifications for FERC to initiate the surcharge. First, and technically, FERC has the authority to approve wholesale electricity and transmission and distribution rates. *See* FERC, *Commission's Responsibilities*, Nov. 26 2008, http://www.ferc.gov/industries/electric.asp (follow "Commission's Responsibilities" hyperlink). Secondly, FERC has also been given authority by Congress to determine electricity charges under 18 C.F.R. § 382.201(b). Moreover, Jon Wellinghoff, the Commissioner of FERC, recently stated that FERC has the authority to intervene in electricity markets to order to ensure that electricity rates are "just and reasonable." The water surcharge could be justified on the grounds that it makes electricity rates more "just." *See* Jon Wellinghoff and David L. Morenoff, *Recognizing the Importance of Demand Response: The Second Half of the Wholesale Electric Market Function*, 28 ENERGY L.J. 392, 392 (2007). Lastly, the enactment of the Energy Policy Act of 2005 explicitly authorized FERC to promote use of demand response and distributed generation, making it national policy to eliminate unnecessary barriers to these technologies in energy, capacity, and ancillary services markets. The water surcharge could be justified on the grounds that it promotes more efficient electricity use. *See id.* at 396.

278. FERC retains the power to levy "discountable Third Party Surcharges" along with

gas consumption,[279] and to fund repairs after Hurricane Katrina.[280] The revenue from a National Electricity Water Policy Surcharge could be used to fully fund government-sponsored research aimed at identifying future National Electricity-Water Crisis Areas.[281]

The Executive Order could finally establish a National Electricity Water Policy Program Office at FERC in Washington, D.C. This Program Office would manage the revenue from the National Electricity Water Policy Surcharge, and advise and assist local and state water managers and energy policymakers in their efforts to rapidly deploy clean power technologies throughout their jurisdiction in all National Electricity-Water Crisis Areas. The Program Office could chair a cabinet-level National Electricity Water Policy Interagency Task Force consisting of water and energy policy experts from the national laboratories, DOE, Department of Agriculture, Department of Interior, EPA, Office of the Federal Environmental Executive, Council on Environmental Quality, Federal Energy Management Program, and USGS. This Task Force would coordinate and harmonize federal laws to stimulate the expedited implementation, permitting and siting of clean power facilities in all federal lands within or adjacent to National Electricity-Water Crisis Areas.

A brief summary of the proposed Executive Order is presented in Table 4.

"commodity surcharges" as part of their setting of natural gas tariffs. *See* FERC, Natural Gas Pipeline Co. of America, Seventh Revised Volume Tariffs No. 1, Apr. 18, 2008, at 1, *available at* http://www.ferc.gov/industries/gas/gen-info/fastr/HTMLAll/024758_000110/024758_000110_000088.htm.

279. FERC also charges natural gas consumption surcharges, and permits states and other public utilities to charge natural gas consumption charges to fund energy research and development, education and information programs relating to natural gas, and payment plans for low income customers. *See* JOHN A. HARVEY, IOWA UTILITIES BOARD, FACTS CONCERNING THE NATURAL GAS INDUSTRY 28 (Oct. 2000); NATIONAL REGULATORY RESEARCH INSTITUTE, NATURAL GAS INFORMATION TOOLKIT 12, 24 (2008).

280. This charge is known as the "Hurricane Mitigation and Reliability Enhancement" surcharge. *See* FERC, Hurricane Mitigation and Reliability Enhancement Adjustment and Waiver Request 1-3.(Mar. 20, 2009)

281. This research would focus on projecting trends in population growth, electricity use, and water use in all major metropolitan areas, and estimate future water consumption and withdrawals related to thermoelectric power plant additions. It would also forecast the technical, economic, and achievable potential for energy efficiency programs, onshore and offshore wind farms, and solar PV systems. Finally, it would solicit grant proposals from major universities that have expertise in GIS modeling, sustainable water management, and/or energy policy.

Table 4: Components of the Proposed Executive Order

Task	Explanation	Goal
Designate National Electricity-Water Crisis Areas	Immediately designate all 22 areas of the country expecting significant water shortages resulting from power plant additions in 2025 as National Electricity-Water Crisis Areas (These Areas are identified in Part II)	Force synergistic thinking on energy-water problems
Prohibit Future Thermoelectric Capacity Additions	Place an immediate moratorium on the relicensing and approval of thermoelectric capacity upgrades or additions in identified National Electricity-Water Crisis Areas	Prevent further water shortages related to power plants
Authorize a National Electricity Water Policy Surcharge	Authorize the Federal Energy Regulatory Commission to implement a "National Electricity Water Policy Surcharge" of 0.001¢/kWh levied on every unit of wholesale electricity generated in the U.S. This revenue would be used to fully fund government-sponsored research.	Fund much needed government R&D
Establish a National Electricity Water Policy Program Office	This program office, established at FERC, would manage the revenue from the National Electricity Water Policy Surcharge, advise and assist local and state policymakers in their efforts to rapidly deploy clean power technologies throughout their jurisdiction in all National Electricity-Water Crisis Areas, and	Deploy clean power technologies on federal lands and assist local and state regulators to do the same within their

	chair a cabinet-level National Electricity Water Policy Interagency Task Force.	own jurisdiction

Such an Executive Order, if implemented in 2007, would have raised about $385 million in annual funds, enough to manage most (if not all) of the components above.[282] We realize the plan is ambitious, but an Executive Order appears to be the best type of action for the task at hand.

C. The Advantages of an Executive Order

An Executive Order has four distinct advantages over other types of local, state, and congressional action: speed, justice, symbolism, and precedence.

1. Speed

Consider the speed with which Executive Orders can be implemented, especially on matters relating to energy and the environment. Congressional deliberations and court decisions typically take months and sometimes even years. Congress is typically in session only 151 days out of the year, regulators spending the rest of their time lobbying and traveling.[283] Anybody that remembers a basic civics class also knows that it takes awhile for a bill to become a law. First, legislation must be introduced in the House or Senate and debated. Next, it often goes to Conference Committee if the two branches cannot agree. Then, if passed, it goes to the President, who has the option of suggesting revisions or vetoing it, or sitting on it for ten days and letting it pass without his or her signature.[284]

282. In 2007, the electric utility industry, which includes all electric utilities, independent power providers, and combined heat and power producers, generated 4,156,745 thousand mega-watt hours. *See* EIA, 2007 ELECTRIC POWER ANNUAL, *supra* note 32, at tbl.1.1, Net Generation by Energy Source by Type of Producer, 1996 through 2007, *available at* http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html. A surcharge of 0.001¢/kWh would have raised about $416 million.

283. *See Days in Session Calendars*, January 3, 2008, http://thomas.loc.gov/home/ds/ (indicating that Congress is in session about 150 days out of each year).

284. For readers that may need a little reminding, *see* TRACIE EGAN, HOW A BILL BECOMES A LAW 1–32 (2003).

All of this creates significant delays. For instance, discussions about the Energy Policy Act of 2005 began in 1999, with the George W. Bush Administration releasing its recommendations for legislation on May 8, 2001, through a report from the National Energy Policy Development Group.[285] But the final version of legislation was not introduced until April 18, 2005, and was first signed into law August 8, 2005.[286] It took roughly five years for a successful bill to be introduced and another 180 days for it to be debated, amounting to a total of 1,915 days between the time it was first conceived and the time it was implemented.

Looking at five influential water and energy bills, and the average time of deliberation and passage (including the Energy Policy Act of 2005) was 1,271 days. It took about 2,920 days for the Federal Air Pollution Program of 1955 to become codified into the country's first national clean air legislation, the Clean Air Act of 1963.[287] The Clean Water Act of 1972 took about 730 days to debate, and the Public Utilities Regulatory Policy Act of 1978 needed about 540 days.[288] Plans for the Clean Air Act Amendments of 1990 were first announced on June 12, 1989 and introduced on August 3, 1989, but not passed until November 15, 1990—taking 518 days.[289] Bills aiming at national electric utility restructuring were first introduced in January 1989, but the Energy Policy Act of 1992 codifying those recommendations was not implemented until October 24, 1992, or about 1,005 days later.[290] Indeed, from 1987 to 1990, one study assessing data on legislative rulemaking found that the average length of time it took policymakers to negotiate

285. *See* NAT'L ENERGY POL'Y DEV. GROUP, NATIONAL ENERGY POLICY (2001), *available at* http://www.ne.doe.gov/pdfFiles/nationalEnergyPolicy.pdf.

286. *See* Energy Policy Act of 2005, Pub. L. No. 109-58, 109 Stat. 594 (2005), *available at* http://www.epa.gov/oust/fedlaws/publ_109-058.pdf.

287. The Federal Air Pollution Program of 1955 was implemented July 14, 1955, whereas the Clean Air Act of 1963 was finally passed on December 17, 1963. *See* U.S. ENVTL. PROT. AGENCY, HISTORY OF THE CLEAN AIR ACT, http://www.epa.gov/air/caa/caa_history.html (last visited Mar. 13, 2009); ARNOLD W. REITZE, J.B. SHAPIRO & MAURICE C. SHAPIRO, STATIONARY SOURCE AIR POLLUTION LAW 8 (2005).

288. For a history of how PURPA became law, *see generally* P.L. Joskow, *Public Utility Regulatory Policy Act of 1978: Electric Utility Rate Reform,* 19 NAT. RES. J. 787, 787–810 (1979); *see also* http://thomas.loc.gov/cgi-bin/bdquery/R?d095:FLD002:@1(95+617).

289. Press Release, EPA, EPA Administrator Reilly Hails Signing of New Clean Air Act (Nov. 15, 1990), *available at* http://www.epa.gov/history/topics/caa90/02.htm.

290. *See President signs energy bill,* SCIENCE NEWS, Nov. 21, 1992, http://findarticles.com/p/articles/mi_m1200/is_n21_v142/ai_12940385/pg_1.

laws and revisions to rules in all areas of legislation was 2.1 to 3.0 years (or 766 to 1,095 days).[291]

Executive Orders also save time in a second sense. The President does not have to expend scarce political capital trying to persuade Congress to adopt his or her proposal. Executive Orders thus save presidential attention for other topics. Executive Orders bypass congressional debate and opposition, along with all of the horse-trading and compromise such legislative activity entails.[292]

Speediness of implementation can be especially important when challenges require rapid and decisive action. After the September 11, 2001 attacks on the Pentagon and World Trade Center, for instance, the Bush Administration almost immediately passed Executive Orders forcing airlines to reinforce cockpit doors and freezing the U.S. based assets of individuals and organizations involved with terrorist groups.[293] These actions took Congress nearly four months to debate and subsequently endorse with legislation. Executive Orders therefore enable presidents to rapidly change law without having to wait for congressional action or agency regulatory rulemaking.

2. Justice

When issues are extremely contentious and legislation is unlikely to pass Congress, Executive Orders can be instrumental in promoting progressive policy and ensuring that at least something is done. Because of the vast and entrenched interests associated with the existing electricity industry, electricity policy is highly politicized. Reforms, statistically, have had little chance of succeeding. Greenpeace estimated that American oil, natural gas, and coal companies spend approximately $31 million every year on lobbying and campaign contributions.[294] During important

291. Cary Coglianese, *Assessing Consensus: The Promise and Performance of Negotiated Rulemaking*, 46 DUKE L.J. 1282, 1270–71 (1997) (noting that remaking time often averages 1–2 years followed by debate and revision).

292. Steven Ostrow, *Enforcing Executive Orders: Judicial Review of Agency Action under the Administrative Procedure Act*, 55 GEO. WASH. L. REV. 659, at 659 (1987).

293. Exec. Order Nos. 13,223, 13,224, and 13,225 all responded to the September 11 attacks within three weeks. *See* Exec. Order No. 13,223, 66 Fed. Reg. 48,201 (Sept. 14, 2001); Exec. Order No. 13,224, 66 Fed. Reg. 49,079 (Sept. 23, 2001); and Exec. Order No. 13,225, 66 Fed. Reg. 50,291 (Sept. 28, 2001).

294. GREENPEACE, OILING THE MACHINE: FOSSIL FUEL DOLLARS FUNNELED INTO THE U.S.

elections the numbers jump significantly: oil and gas companies contributed about $255 million to political campaigns and electric utilities an additional $20 million for the 2004 election cycle. From 2003 to 2006, fossil fuel lobbyists contributed about $58 million to state-level campaigns alone. Over the same period, renewable energy lobbyists spent just over $500,000.[295] Consequently, from 1997 to 2006, federal bills promoting a national renewable portfolio standard (a law forcing utilities to use clean power) were introduced in Congress but failed to pass no less than 17 times, and from 1997 to 2004, more than one-hundred legislative proposals dealing with climate change were introduced into Congress but were all defeated.[296]

The courts and Congress, in other words, do not want to deal with potentially controversial issues. Given the politicized nature of interstate conflicts over environmental pollution, Noah D. Hall argues that "the Supreme Court does not want the job, especially when technical and scientific uncertainty dominates these disputes."[297] Congress, in turn, has rarely taken formal action on those states violating the Clean Air Act and the Clean Water Act, and is often reluctant to take on heated interstate controversies.[298] This could be an especially important concern in areas of water policy, since the states with the largest populations will also have the most significant water needs and the most sway in Congress, giving them somewhat disproportionate control over the national water agenda. An Executive Order is a logical alternative given the constraints faced by environmental and energy related legislation and Supreme Court rulings.

3. Symbolism

Executive Orders can often send a stronger signal—both

POLITICAL PROCESS (1997), *available at* http://archive.greenpeace.org/climate/industry/reports/machine.html.

295. Megan Moore, Nat'l Inst. on Money in State Politics, *Energy & Environmental Giving in the States* 2 (2007), *available at* https://www.policyarchive.org/bitstream/handle/10207/5817/200705231.pdf.

296. Benjamin K. Sovacool & Jack Barkenbus, *Necessary But Insufficient: State Renewable Portfolio Standards and Climate Change Policies*, 49 ENV'T 20, 23 (2007).

297. Noah D. Hall, *Political Externalities, Federalism, and a Proposal for an Interstate Environmental Impact Assessment Policy*, 32 HARV. ENVTL. L. REV. 49, 70 (2008).

298. *Id.*

domestically and globally—than either legislation or court action. The Office of the President holds deep symbolic meaning for many Americans. Presidential action can influence public opinion, especially since most citizens perceive the President as the paradigmatic leader of the country as the Commander-in-Chief of its armed forces.[299] Presidential leadership, coupled with its frequent monopoly of media attention, means that presidential action brings with it an enhanced level of effectiveness.[300] Moreover, presidential action often has greater international significance. The President and cabinet officials meet with foreign leaders and officials far more frequently than do agents of Congress or the courts, and they do so in smaller and less-public settings, meaning that their actions are more likely to influence the global agenda.[301]

In this type of a situation, when entrenched interests and shortsightedness have bogged down policymaking, Presidential action can promote progressive change and justice. Thomas Jefferson issued an Executive Order in 1803 to complete the Louisiana Purchase; President Lincoln issued an Executive Order in 1863 to free the slaves (an action later known as the "Emancipation Proclamation"); President Truman used an Executive Order to force the racial integration of the armed forces; President Eisenhower used one to force all federal contractors to post public notice of their nondiscrimination in hiring; Presidents Kennedy and Johnson used Executive Orders to require affirmative action in federal contracting and to ban racial discrimination in federal housing; and President Nixon used an Executive Order to create the EPA.[302]

In each of these circumstances, Executive Orders were used to cut through partisanship and implement important and needed

299. *See generally* JAMES L. FISHER & JAMES V. KOCH, PRESIDENTIAL LEADERSHIP: MAKING A DIFFERENCE (1996).

300. JIM RIDDLESPERGER, PRESIDENTIAL LEADERSHIP AND CIVIL RIGHTS POLICY 16–19 (1995).

301. Ostrow, *supra* note 287, at 659.

302. For a full listing of all Executive Orders, *see* National Archives, Executive Orders Dispositions Table Index, http://www.archives.gov/federal-register/executive-orders/disposition.html (last visited Mar. 13, 2009); *see also* RUTH P. MORGAN, THE PRESIDENT AND CIVIL RIGHTS: POLICYMAKING BY EXECUTIVE ORDER (1970); Kenneth Mayer & Kevin Price, *Unilateral Presidential Powers: Significant Executive Orders, 1949–99*, 32 PRESIDENTIAL STUDIES QUARTERLY 367, 375–81 (2002).

changes. Furthermore, such Executive Orders often catalyzed media and public attention to the degree that they later persuaded Congress to endorse with eventual legislation. Bruce N. Reed, a special advisor to President Clinton, put it succinctly by stating that "in our experience, when the administration takes executive action, it not only leads to results while the political process is stuck in neutral, but it often spurs Congress to follow suit."[303] Analogously, Executive Orders, notes two political scientists, "facilitate innovations in the legislative process, codify ideological commitments, and drive social change."[304]

4. Precedence

Finally, and most importantly, there is historical precedence for Executive Orders dealing with energy and environmental issues. President Roosevelt issued Executive Orders on environmental matters on no less than 1,147 occasions, and since then more than 20 percent of all Executive Orders have addressed issues relating to the environment.[305] President Clinton issued 34 Executive Orders related to the environment and natural resources.[306] The establishment of the Northwestern Hawaiian Island Coral Reef Ecosystem Reserve, banning of the use of off road vehicles in Wilderness Areas, outlawing of road building in national forests, blacklisting of facility owners convicted of environmental offenses from receiving federal contracts, creation of grants and leases to preserve wetlands, and enhanced protections for federal lands have all occurred by Executive Order.[307]

At least three Executive Orders have even created interagency task forces in areas relating to energy policy and water management in the past seven years. In 2001, President George W.

303. Marc Lacey, *Blocked by Congress, Clinton Wields a Pen*, N.Y. TIMES, July 5, 2000, at A13, *available at* http://query.nytimes.com/gst/fullpage.html?res=9E03E4DD1139F936A35754C0A9669C8B63.

304. Mayer & Price, *supra* note 297, at 375.

305. William H. Rodgers, Jr., *Executive Orders and Presidential Commands: Presidents Riding to the Rescue of the Environment*, 21 J. LAND RES. & ENVTL. L. 13, 19 (2001).

306. *Executive Orders and Presidential Directives: Hearing on H.R. 2655 Before the H. Comm. on the Judiciary*, 107th Cong. (2001) (statement of Todd F. Gaziano, Dir., Ctr. for Legal and Judicial Studies, The Heritage Found.), *available at* http://www.heritage.org/Research/GovernmentReform/Test032201.cfm.

307. Rodgers, *supra* note 305, at 19-20.

Bush signed an executive order to create a White House Task Force on Energy Project Streamlining, which managed energy permitting projects for hydroelectric power stations, interstate oil and gas pipelines, electric transmission and distribution lines, and offshore exploration of oil and gas reserves.[308] A few years later, in 2004, the President issued an Executive Order establishing an interagency federal task force to address environmental and water challenges in the Great Lakes.[309] Most recently, in January 2007, the President issued an Executive Order that created an interagency task force to oversee and coordinate energy efficiency improvements and environmental conservation at federal facilities.[310]

In each of these three cases—dealing with the environmental problems facing the Great Lakes, streamlining siting and permitting for energy projects, and improving the sustainability of federal buildings—interagency task forces were created by Executive Order. These Executive Orders did not directly flow from Congressional authorization or even deliberation, nor were they challenged on constitutional grounds, implying that the Executive Order proposed here would be legitimate. Furthermore, past reliance on Executive Orders to respond to pressing energy or environmental problems suggests that when environmental problems are multi-state or fall on many jurisdictions or agencies, Executive Orders can provide quick, clear, and decisive federal action.

Obviously, the recent 2008 Presidential and Congressional elections may motivate stronger support for more progressive energy, climate, and water policies. However, four factors warn against the optimism that a Barack Obama Administration and a Democratic Congress can act quickly on electricity-water issues.

308. President Bush signed Executive Order 13212, "Actions to Expedite Energy-Related Projects," on May 18, 2001. Exec. Order No. 13,212, 66 Fed. Reg. 28,357 (May 18, 2001); *see also* White House Task Force on Energy Project Streamlining, *Proceedings of the First Year White House Task Force on Energy Project Streamlining* (Dec. 2002).

309. The President issued Executive Order 13340, "Establishment of Great Lakes Interagency Task Force & Promotion of a Regional Collaboration of National Significance for the Great Lakes," on May 18, 2004. Exec. Order No. 13,340, 69 Fed. Reg. 29,043 (May 18, 2004).

310. On January 24, 2007, the President passed Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management." Exec. Order No. 13,423, 72 Fed. Reg. 3,919 (Jan. 24, 2007); *see also* INSTRUCTIONS FOR IMPLEMENTING EXECUTIVE ORDER 13423 (2007), *available at* http://www.ofee.gov/eo/eo13423_instructions.pdf.

The first is the immediacy of the financial crisis, which will likely occupy most of Congress's attention in the short-term.[311] The second is that Congress and the President may expend most of the political capital they have with potential opponents trying to pass a climate change bill,[312] and not a progressive electricity-water bill. The third is that the Democrats, while perhaps more amenable to environmental legislation, still do not have filibuster-proof control of the Senate.[313] The fourth is that the Democratic leadership has, in the past, not guaranteed passage of renewable energy and climate bills: no energy and climate bills passed Congress during the final two years of the Clinton Administration (1998 to 2000), and from 2006 to 2008 Democratic control of the House and Senate also failed to precipitate in any active climate legislation.[314]

CONCLUSION

The satirist G.K. Chesterton once remarked that when there are not enough hats to go around, the problem is not solved by chopping off some heads. Ostensibly, it is best addressed by making more hats. In a similar context, when the water needs of existing conventional power plants are already so significant that they will likely force water shortages in the future, the problem is not solved by "chopping off our heads" by building more water intensive power plants. The solution is to seek a more benign and sensible alternative.

From a water use perspective, conventional thermoelectric generators are wasteful and destructive: they withdraw and

311. *See Obama: Financial Crisis a Major Threat to Economy*, REUTERS NEWS SERV., Sept. 15, 2008, *available at* http://www.reuters.com/article/topNews/idUSN1551961320080915 (noting that the financial crisis will be one of the most important issues dealt with by a new administration); *see also Obama Taps Volcker to Head Panel on Crisis*, REUTERS NEWS SERV., Nov. 26, 2008, *available at* http://www.reuters.com/article/vcCandidateFeed2/idUSTRE4AP5O320081126 (noting that President Obama is personally invested in addressing the financial crisis); Tim Harper, *Obama Builds Brain Trust to Tackle Financial Crisis*, TORONTO STAR, Nov. 25, 2008, *available at* http://www.thestar.com/News/World/article/542832 (noting that President Obama intends immediately address the crisis as soon as he can in 2009).

312. *See Obama Will Act Quickly on Climate Change*, REUTERS NEWS SERV., Nov. 12, 2008, *available at* http://www.reuters.com/article/environmentNews/idUSTRE4AB84K20081112.

313. *See* CNN, Election Center 2008, Senate Full Results, http://edition.cnn.com/ELECTION/2008/results/main.results/#S (last visited Feb. 11, 2009).

314. *See* Sovacool & Barkenbus, *supra* note 296.

consume vast amounts of water; pollute and contaminate water supplies; emit airborne and climate changing pollutants; and ultimately reduce water availability, degrade water quality, and alter precipitation patterns. Despite the sensitivity needed to respond to electricity-water problems, policymakers at all levels of government are doing little to address them. A sharp divide between electricity and water policy still occurs in how must regulators conceive of and approach their respective policymaking functions. Far too few recognize the synergy between the two, and most of those that do often fail to talk about clean power as a solution. Conventional alternatives such as wet and dry cooling systems, reusing nontraditional sources of water, diffusion driven desalination, flue gas capture, and clean coal systems would still commit the industry to a water-intensive supply chain. Water would be needed for the exploration, cleaning, mining, and enrichment of coal, gas, oil, and uranium; for cooling, maintenance, and emissions controls; and to purge boilers and maintain the integrity of carbon sequestration and storage sites.

The federal government must intervene. Continued water use from conventional power plants is a national issue, not just because of the magnitude of the metropolitan areas at risk, but also because of the interstate nature of electricity and water. Rivers, streams, lakes, and transmission and distribution power lines transcend individual state boundaries. It is thus inappropriate for states and cities to address water and electricity problems on their own. Given the speed at which electricity-water problems can worsen, we believe the President should address the matter through an Executive Order establishing National Electricity-Water Crisis Areas and creating an interagency task force at FERC. Such intervention may seem unjust to those regions that have poorly planned their electricity-water needs, but as Garret Hardin wrote in 1968, "injustice is preferable to total ruin."[315]

315. Garrett Hardin, *The Tragedy of the Commons*, 162 SCI. 1243, 1247 (1968).

APPENDIX 1: EXECUTIVE ORDER 13XXX, "DESIGNATION OF NATIONAL ELECTRICITY-WATER CRISIS AREAS AND CREATION OF THE NATIONAL ELECTRICITY WATER POLICY PROGRAM OFFICE"

By the authority vested in me as President by the Constitution and the laws of the United States of America, and in order to take additional steps to improve the management of water supplies and the availability of electricity to our Nation, it is hereby ordered as follows:

Section 1. Policy

The use of water for drinking, agriculture, and industry, along with the increased production and transmission of electricity in a safe and environmentally sound manner, is essential to the well-being of the American people. In general, it is the policy of this Administration that executive departments and agencies shall take appropriate actions, to the extent consistent with applicable law, to ensure the sustainable management of water and electricity resources.

Sec. 2. Designation of National Electricity-Water Crisis Areas

The Federal Energy Regulatory Commission will immediately designate all areas of the country expecting significant water shortages resulting from power plant additions in 2025 as "National Electricity-Water Crisis Areas." It will also place an immediate federal moratorium on the relicensing and approval of thermoelectric capacity upgrades or additions in identified National Electricity-Water Crisis Areas.

Sec. 3. National Electricity Water Policy Surcharge

The Federal Energy Regulatory Commission will immediately implement a "National Electricity Water Policy Surcharge" of 0.001¢/kWh levied on every unit of wholesale electricity generated in the U.S. This revenue would be used to fully fund government-sponsored research aimed at identifying future National Electricity-Water Crisis Areas, with an emphasis on projecting trends in population growth, electricity use, and water use in all major metropolitan areas; estimating future water consumption and withdrawals related to thermoelectric power plant additions; forecasting the technical, economic, and achievable potential for energy efficiency programs, onshore and offshore wind farms, and solar photovoltaic systems; and soliciting grant proposals from major universities that have expertise in GIS modeling and/or sustainable water management and energy policy.

Sec. 4. National Electricity Water Policy Program Office and Interagency Task Force

There is established a National Electricity Water Policy Program Office at the Federal Energy Regulatory Commission in Washington, DC. This Program Office will manage the revenue from the National Electricity Water Policy Surcharge. It will advise and assist local and state policymakers in their efforts to rapidly deploy clean power technologies throughout their jurisdiction in all National Electricity-Water Crisis Areas. It will chair a cabinet-level National Electricity Water Policy Interagency Task Force, consisting of water and energy policy experts from the national laboratories, Department of Energy, Department of Agriculture, Department of Interior, Environmental Protection Agency, Office of the Federal Environmental Executive, Council on Environmental Quality, Federal Energy Management Program, and United States Geological Survey, to coordinate and harmonize federal laws to stimulate the expedited implementation, permitting and siting of energy efficiency programs, onshore and offshore wind technologies, and solar photovoltaic facilities in all federal lands within National Electricity-Water Crisis Areas. It will educate consumers and distribute public information about the water-electricity nexus to create consistent and acceptable messages concerning the water needs associated with electricity use. The Program Office will prepare a report on the feasibility of phasing out all thermoelectric power generation by 2050, as well as the potential social and economic costs and benefits of such a phase-out.

Sec. 5. Judicial Review

Nothing in this order shall affect any otherwise available judicial review of agency action. This order is intended only to improve the internal management of the Federal Government and does not create any right or benefit, substantive or procedural, enforceable at law or equity by a party against the United States, its agencies or instrumentalities, its officers or employees, or any other person.

Sec. 6.

This order is effective immediately and shall be promptly transmitted to Congress and published in the Federal Register.

Signed, President of the United States of America, The White House.