

RUNNING ON EMPTY: THE ELECTRICITY-WATER NEXUS AND THE U.S. ELECTRIC UTILITY SECTOR

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Synopsis: This article explores the consequence of the growing water needs of the United States electric utility industry. It argues that an impending scarcity of water could complicate continued reliance on thermoelectric power plants that combust fossil fuels or utilize nuclear fission to generate power. The article begins by explaining the electricity-water nexus and noting how conventional power plants “use” water by withdrawing and consuming it, placing a special emphasis on the different cooling cycles for thermoelectric power plants. The article then focuses on how the water needs of the electricity industry may engender a series of water and power crises in eight future metropolitan areas—Atlanta, Charlotte, Chicago, Denver, Houston, Las Vegas, New York, and San Francisco—where water resources will be scarce or declining, especially if electricity demand grows as expected. The final part of the article emphasizes what electric utilities can do to minimize their water needs, particularly by halting all future thermoelectric power plant construction, promoting energy efficiency, deploying renewable power stations, and distributing information and more accurate price signals to electricity customers.

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INTRODUCTION

During the drought of 2002, lawmakers in Idaho ruled that five large coal- and gas-fired power plants should be denied water rights for cooling because they would deplete much needed freshwater for drinking and irrigation.¹ In Nevada, the 1,580 megawatt (MW) coal-fired Mohave Generation Station was forced to close in 2005 due to lack of groundwater.² A few years earlier, American National Power had to withdraw its application to build a 1,100 MW natural gas plant near Hillburn, New York, because it created a controversy concerning water rights.³ Far from being isolated examples, water issues have complicated power plant construction or operation in Arizona,⁴ Georgia,⁵ California,⁶ Colorado,⁷ Massachusetts,⁸ Missouri,⁹ New Mexico,¹⁰ North

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

2. United States Water News Online, *Lack of Water May Shut Down Power Plant on Arizona-Nevada Border*, November, 2004 <http://www.uswaternews.com/archives/arcsupply/4lackofxx11.html>.

3. Alex Nussbaum, *Company Ends Fight for Power Generator on New Jersey-New York Border*, THE RECORD (Hackensack, NJ), September 5, 2002 available at http://www.accessmylibrary.com/coms2/summary_0286-7408105_ITM.

4. April Reese, *Western Power Plants Come Under Scrutiny as Demand and Drought Besiege Supplies*, LAND LETTER, March 4, 2004, available at <http://www.eenews.net/Landletter/print/2004/03/04/1>.

5. UNITED STATES DEPARTMENT OF ENERGY, ENERGY DEMANDS ON WATER RESOURCES: REPORT TO CONGRESS ON THE INTERDEPENDENCY OF ENERGY AND WATER (Washington, DC: U.S. DOE, December, 2006), p. 30, available at <http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf> [hereinafter DOE].

6. Mahvish Khan, *Regional Report: California’s Needs for Water and Electricity Pit One Against the Other*, WALL STREET JOURNAL Aug.1, 2001, at B1.

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

8. DOE *supra* note 6, at 30.

9. *Id.*

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

Carolina,¹¹ Pennsylvania,¹² Rhode Island,¹³ South Dakota,¹⁴ Tennessee,¹⁵ Texas,¹⁶ and Wisconsin.¹⁷

The situation underscores a problem as pressing as it is invisible to many electric utilities, water planners, and even ordinary people: burgeoning water use at conventional thermoelectric power plants. Water use for electric power plants increased five-fold from forty billion gallons per day in 1950 to 195 billion gallons per day in 2000.¹⁸ The average power plant in the United States uses about twenty-five gallons of water for every kilowatt-hour (kWh) generated.¹⁹ Given that electric utilities produced 4,159,514 gigawatt-hours (GWh) of power in 2007,²⁰ these power plants ostensibly used 104 trillion gallons of water.²¹ This amount is enough to cover the entire country in two inches of water,²² or to almost completely fill Lake Erie.²³

This article explores the consequence of the growing water needs of the U.S. electric utility industry, and suggests that lack of water during the summer months in many regions could complicate continued reliance on thermoelectric power plants that combust coal, oil, natural gas, and biomass (or utilize nuclear fission) to generate power. Part I begins by noting the electricity-water nexus and explaining how conventional power plants “use” water by withdrawing and consuming it, placing a special emphasis on the different cooling cycles at thermoelectric power plants. Part II then focuses on how the water needs of the industry may engender a series of water and power crises in eight future metropolitan areas—Atlanta, Charlotte, Chicago, Denver, Houston, Las Vegas, New York, and San Francisco—where water resources will be scarce or

11. Bruce Henderson, *Duke Power Warns Towns in Charlotte, N.C., Area to Cut Water Use*, THE CHARLOTTE OBSERVER, Aug. 28, 2002, available at http://findarticles.com/p/articles/mi_hb5553/is_200208/ai_n21664395.

12. DOE *supra* note 6, p. 30.

13. *Id.*

14. *Id.*

15. *Id.*

16. *Id.*

17. *Id.*

18. UNITED STATES GEOLOGICAL SURVEY, ESTIMATED USE OF WATER IN THE UNITED STATES IN 2000, Table 14, 2004, available at <http://pubs.usgs.gov/circ/2004/circ1268/htdocs/table14.html>.

19. Jeff Hoffmann et al., *DOE/NETL's Power Plant Water Management R&D Program—Responding to Emerging Issues*, Presentation at the 8th Electric Utilities Environmental Conference, Tucson, AZ, January 24-26, 2005, available at http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/05_EUEC_Hoffmann_1.pdf.

20. THE EDISON ELECTRIC INSTITUTE, INDUSTRY STATISTICS—2008, available at http://www.eei.org/industry_issues/industry_overview_and_statistics/industry_statistics/index.htm, for example, reports that in 2007 “[t]otal U.S. electricity generation was 4,159,514 gigawatt-hours (GWh)—a 2.3-percent increase from 2006.”

21. To be more precise, these power plants would have used precisely 103,987,850,000,000 gallons of water in 2007.

22. GREAT LAKES INFORMATION NETWORK, *Great Lakes Facts and Figures*, 2008, available at <http://www.great-lakes.net/lakes/ref/lakefact.html>, reports that the Great Lakes contain roughly six quadrillion gallons of water and could cover the nation in 9.5 feet of water; thus 104 trillion gallons would cover the nation in about 0.16 feet, or two inches.

23. Lake Erie is reported to contain only four percent of the volume of Lake Superior, which has 3.2 quadrillion gallons of water, meaning Lake Erie has 128 trillion gallons, close to the 104 trillion gallons used by electricity generations. GREAT LAKES BIODIVERSITY PROJECT, *Meet the Lakes*, 2008, available at <http://greatlakesforever.org/html/meetlakes/fanfacts.html>.

declining, especially if electricity demand continues to grow as expected. Part III emphasizes what electric utilities can do to minimize their associated water needs, particularly by promoting energy efficiency, deploying wind and solar photovoltaic power stations, and distributing information and more accurate price signals to electricity customers. The importance of exploring the electricity-water nexus, its associated challenges, and its possible remedies is threefold.

First, a slew of government agencies and industry groups, including the National Research Council,²⁴ U.S. Geologic Survey,²⁵ U.S. Department of Energy,²⁶ U.S. Department of Interior,²⁷ Electric Power Research Institute²⁸, Sandia National Laboratory²⁹, National Energy Technology Laboratory (NETL),³⁰ and the National Renewable Energy Laboratory,³¹ have recently issued reports focusing on the importance of water use at conventional power plants. These reports, however, mostly argue that better technologies will need to be developed in order to address the industry's growing water needs. The National Research Council calls on the federal government to increase research and development (R&D) funding for innovative energy technologies that utilize less water,³² while both Sandia and NETL discuss treating and reusing brackish water,³³ capturing water vapor from power plants,³⁴ and diffusion driven

24. NATIONAL RES. COUNCIL OF THE NAT'L ACADEMIES, COMM. ON ASSESSMENT OF WATER RES. RESEARCH, *Confronting the Nation's Water Problems: The Role of Research*, The Nat'l Academies Press, 2004, available at <http://www.nap.edu/openbook.php?isbn=0309092582>.

25. Mark T. Anderson & Lloyd H. Woosley, *Water Availability for the Western United States—Key Scientific Challenges* (U.S. Department of Interior, U.S. Geological Survey, Circular 1261, 2005), available at <http://pubs.usgs.gov/circ/2005/circ1261/>.

26. DOE *supra* note 6.

27. UNITED STATES DEPT. OF THE INTERIOR BUREAU OF RECLAMATION, WATER 2025: PREVENTING CRISES AND CONFLICT IN THE WEST (2005, available at <http://www.usbr.gov/water2025/images/Water2025-08-05.pdf> [hereinafter USDIBR]).

28. ELECTRIC POWER RESEARCH INSTITUTE, WATER & SUSTAINABILITY (VOLUME 1): RESEARCH PLAN ((2002, Technical Report 1006784); available at <http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=ObjMgr&parentid=2&control=SetCommunity&CommunityID=221&PageIDqueryComId=0> [hereinafter EPRI]; ELEC. POWER RESEARCH INST., WATER & SUSTAINABILITY (VOLUME 4): U.S. ELECTRICITY CONSUMPTION FOR WATER SUPPLY & TREATMENT—THE NEXT HALF CENTURY (2002, Topical Report 1006787) available at <http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=ObjMgr&parentid=2&control=SetCommunity&CommunityID=221&PageIDqueryComId=0>.

29. SANDIA NATIONAL LABORATORY, THE ENERGY-WATER NEXUS OVERVIEW (2007), available at http://www.sandia.gov/energy-water/nexus_overview.htm.

30. NATIONAL ENERGY TECHNOLOGY LABORATORY, DEPARTMENT OF ENERGY/NATIONAL ENERGY TECHNOLOGY LABORATORY'S POWER PLANT-WATER R&D PROGRAM, (2007), available at http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/Power%20Gen%202006_Water%20R&D.pdf.

31. UNITED STATES NATIONAL RENEWABLE ENERGY LABORATORY, THE WIND-WATER NEXUS (U.S. Dept. of Energy, DOE/GO-102006-2218, 2006).

32. DOE *supra* note 6, pp. 3-18.

33. THOMAS J. FEELEY & LYNN BRICKETT, STRATEGIES FOR COOLING ELECTRIC GENERATING FACILITIES UTILIZING MINE WATER: TECHNICAL AND ECONOMIC FEASIBILITY (NAT'L ENERGY TECH. LAB. FACT SHEET, NETL-98-2005 2005), available at <http://www.netl.doe.gov/technologies/publications/factsheets/project/Proj363.pdf>.

34. NATIONAL ENERGY TECH. LAB., POWER PLANT WATER MGMT. WATER EXTRACTION FROM COAL-FIRED POWER PLANT FLUE GAS-ENERGY & ENV'T'LL RESEARCH CTR. (2008), available at <http://www.netl.doe.gov/technologies/coalpower/ewr/water/pp-mgmt/eerc.html>.

desalination as important technical options.³⁵ Another study argues that the President should issue an Executive Order granting the Federal Energy Regulatory Commission (FERC) authority to designate select parts of the country “National Electricity-Water Crisis Areas.”³⁶ In December 2008, the Supreme Court heard arguments in *Entergy Corporation v. Riverkeeper* for and against strengthening the Environmental Protection Agency’s regulations concerning the intake of water at conventional power plants, but the Court has not yet made its decision and the case concerns only the damage of power plant intake structures to fish and aquatic biodiversity.³⁷ Senators Bingaman and Murkowski even introduced legislation in early 2009 to commission a study on electricity-water problems and produce a roadmap, but their bill is uncertain to pass and again focuses on federal action.³⁸ While focusing on federal research and national legislation is indeed important, equally significant is the role that electric utilities, public utility commissioners, and state regulators can undertake to avoid new thermoelectric power plant construction, invest in energy efficiency and renewable power resources, and alter electricity prices, either in conjunction with or independent of federal action.

Second, despite this collection of reports, existing electricity planners and water managers do not appear to be responding to electricity and water problems quickly or comprehensively. The Clean Air Task Force has also concluded that “water use and consumption have not been significant factors in decisions related to the permitting and siting of power plants.”³⁹ Peter Gleick has noted that “energy and water issues are rarely integrated into policy.”⁴⁰ Neither energy nor water planners are consequently trained to think about electricity and water in a systematic way.⁴¹ Electricity industry advocates continually downplay the importance of clean energy sources for minimizing thermoelectric water consumption. When assessing solutions to reduce the water use from conventional generators, the Electric Power Research Institute, for example,

35. JAMES F. KLAUSNER & RENWEI MEI, INNOVATIVE FRESH WATER PRODUCTION PROCESS FOR FOSSIL FUEL PLANTS: ANNUAL REPORT, DOE AWARD NUMBER DE-FG26-02NT41537, 2003, available at http://www.fischer-tropsch.org/DOE/DOE_reports/FG26-02NT41537/FG26-02NT41537-1/FG26-02NT41537-1_toc.htm.

36. Benjamin K. Sovacool & Kelly E. Sovacool, *Preventing National Electricity-Water Crisis Areas in the United States*, COLUM. J. ENVTL. L. (forthcoming, May 2009).

37. See, e.g., Debra Weiss, *Supreme Court Mulls Meaning of “Best” in Environmental Case*, A.B.A. J. LAW NEWS (2008), available at http://abajournal.com/news/supreme_court_mulls_meaning_of_best_in_environmental_case/; and Kristen Henderson and Max Schwartz, *Entergy Corp. v. EPA: Briefs and Documents* (2008), available at http://www.scotuswiki.com/index.php?title=Entergy_Corp._v._EPA.

38. The bill, S. 531, is tentatively titled the Energy and Water Integration Act of 2009 and would require the National Academy of Sciences to commission a study on energy and water, direct the DOE to identify best available technologies, promote water reclamation at power plants, look into research on desalination, refine EIA reporting guidelines for water use at power facilities, and direct the Secretary of Energy to develop an energy-water research roadmap.

39. CLEAR AIR TASK FORCE AND LAND AND WATER FUND OF THE ROCKIES, THE LAST STRAW: WATER USE BY POWER PLANTS IN THE ARID WEST (The Hewlett Foundation, April, 2003) available at http://www.catf.us/publications/reports/The_Last_Straw.pdf.

40. Peter H. Gleick, *Water and Energy (and Climate): Critical Links*, Pacific Institute, 2008 at 1 available at <http://dels.nas.edu/besr/docs/Gleick.pdf>.

41. Peter H. Gleick, *Water Use*, ANNUAL REVIEW OF ENVIRONMENT & RESOURCES 28 (2003), pp. 275-314.

mentions variable speed electric drives, advanced membranes, ozone disinfection, electroseparation, and freeze-thaw wastewater treatment as important water technologies, but not energy efficiency, demand side management, or renewables.⁴² Conversely, an influential RAND report⁴³ on water management focuses exclusively on tools such as “supply management” (including the location, development, and exploitation of new sources of water such as building new dams and control structures, desalination plants, arranging for inter-basin transfers of water, reclamation and reuse) and “demand management” (such as water quality matching, privatization, and water pricing) but never once mentions energy policy tools or more efficient power plants.⁴⁴ This article is an important call for more synergistic thinking that views electricity and water problems as interconnected, especially insofar that energy efficiency and renewable power plants can simultaneously reduce demand for electricity and improve the availability of water.

Third and finally, the challenges related to water scarcity and electricity are not confined to the United States. The Central Intelligence Agency believes that more than three billion people will be living in water-stressed regions around the world by 2015 (with a majority concentrated in North Africa and China). Water tables for major grain producing areas in northern China are dropping at a rate of five feet per year, and per capita water availability in India expected to drop fifty to seventy-five percent over the next decade.⁴⁵ The American Museum of Natural History reports that about 900 million people spread across twenty-seven developing countries already lack adequate access to water.⁴⁶ Thus, an exploration of how utilities in the United States may respond to electricity-water crises can offer policymakers insight into how the industry can address what is sure to become a pressing global dilemma.

PART I: THE ELECTRICITY WATER NEXUS

Almost all conventional power plants, including coal, oil, natural gas, and nuclear facilities, employ one of three types of cooling cycles in their generation of electricity. Once-through cooling systems withdraw water from a source, circulate it, and return it to the surface body. Re-circulating or closed-loop systems withdraw water and then recycle it within the power system instead of discharging it. Dry cooling systems, which are not widely adopted, use air instead of water to cool power stations.

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. After it passes through the plant, heated and treated water is then discharged

42. EPRI *supra* note 29.

43. JIL BOBERG, *LIQUID ASSETS: HOW DEMOGRAPHIC CHANGES AND WATER MGMT. POLICIES AFFECT FRESHWATER RES.* (Santa Monica, CA: Rand Corporation, 2005).

44. *Id.* at 21.

45. Carl Pope, *The State of Nature: Our Roof is Caving In*, FOREIGN POLICY 67 (2005), available at http://www.heartland.org/custom/semod_policybot/pdf/17739.pdf.

46. AMERICAN MUSEUM OF NATURAL HISTORY, *WATER: H₂O=LIFE* (2007), available at http://amnh.org/exhibitions/water/?section=noranydrop&page=noranydrop_b.

downstream from its point of intake to a receiving body of water.⁴⁷ Since such cooling systems release heated water back to the source, they can further contribute to evaporative loss by raising the temperature of receiving water bodies.⁴⁸ Once-through systems are responsible for withdrawing ninety-one percent of the nation's water used for power plants, and are also utilized by more than half of the country's fleet of nuclear reactors.⁴⁹

Re-circulating or closed-loop systems, by recycling water, withdraw much less of it but tend to consume more. To maintain plant performance, water is frequently discharged from the system at regular intervals into a receiving body of water or collection pond, but is otherwise recycled as much as possible. Since it is being reused, the water requires more chemical treatment to eliminate naturally occurring salts and solids that accumulate as water evaporates. Closed-loop systems also rely on greater amounts of water for cleaning and therefore return less water to the cooling cycle.⁵⁰

Dry-cooling, an approach that replaces evaporative cooling towers in closed-loop systems with cooling towers dependent entirely on air, works best in colder weather and in arid environments.⁵¹ Only a very small number of plants rely on dry cooling, since they lower plant efficiency and cost the most.⁵²

When taken together, the once-through, closed, and dry cooling systems in place at these power plants use a significant amount of water. (The term "use" encompasses both water consumption⁵³ and water withdrawal).⁵⁴ Using the most recently available data from the U.S. Geologic Survey,⁵⁵ thermoelectric power plants used more than 195 billion of these gallons of water per day, or forty-seven percent of the nation's total, in 2000 (See Figures 1 and 2). According to the U.S. Geologic Survey, water withdrawals for thermoelectric generators differ greatly by state. When looked at geographically, Texas withdrew the largest amount of water; Illinois, Texas, and Tennessee accounted for twenty-two percent of all total freshwater withdrawals; and California and Florida accounted for more than forty percent of saline surface water withdrawals (See Table 1 and

47. Ellen Baum, *Wounded Waters: the Hidden Side of Power Plant Pollution*, CLEAN AIR TASK FORCE, 2, 3, (2004) available at http://www.catf.us/publications/reports/Wounded_Waters.pdf [hereinafter Baum].

48. *Id.*

49. LINDA GUNTER ET AL., LICENSED TO KILL: HOW THE NUCLEAR POWER INDUSTRY DESTROYS ENDANGERED MARINE WILDLIFE AND OCEAN HABITAT TO SAVE MONEY (Grace Foundation and Norcross Foundation 2001), available at <http://www.nirs.org/reactorwatch/licensedtokill/LiscencedtoKill.pdf>.

50. NREL, *supra* note 32.

51. Baum, *supra* note 46.

52. THOMAS J. FEELEY & BARBARA CARNEY, INNOVATIVE APPROACHES AND TECHNOLOGIES FOR IMPROVED POWER PLANT WATER MANAGEMENT (Nat'l Energy Tech. Lab., Program Facts, 2005), available at <http://www.netl.doe.gov/publications/factsheets/program/Prog055.pdf>.

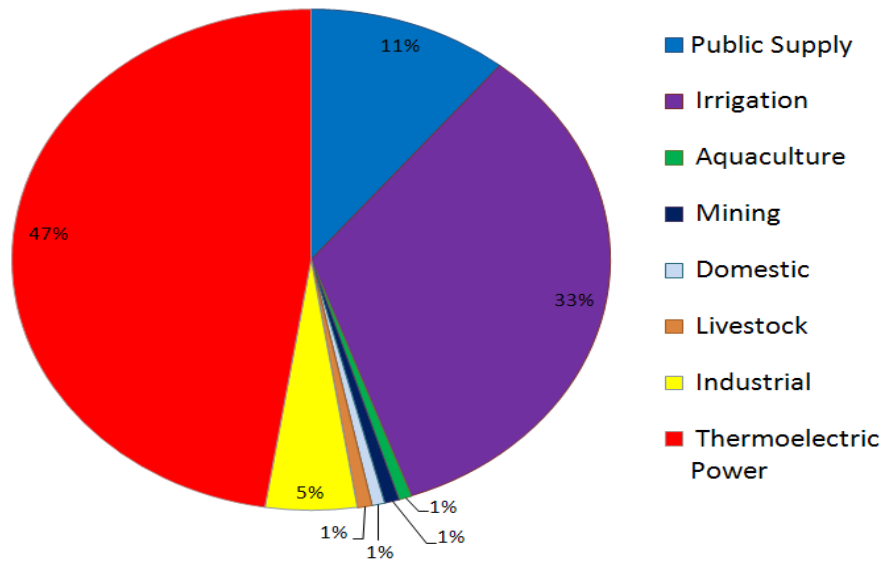
53. The term "consumption" refers to the direct loss of freshwater, surface water, or ground water to cool power plants. Water is not returned to its source and is completely removed from local water sources.

54. The term "withdrawal" refers to the removal of freshwater, surface water, or groundwater from rivers, lakes, streams, and reservoirs to cool power plant equipment before it is returned to its source.

55. The author reluctantly had to rely on 2000 data from the USGS because the agency is still in the process of collecting and compiling data from 2005 (the agency expects this new data to be available in late 2009). See, e.g., U.S. GEOLOGIC SURVEY, WATER USE IN THE UNITED STATES, available at <http://water.usgs.gov/watuse/>.

Figure 3). This means that, on average, thermoelectric generators use more water than the entire country's agricultural and horticultural industry.⁵⁶

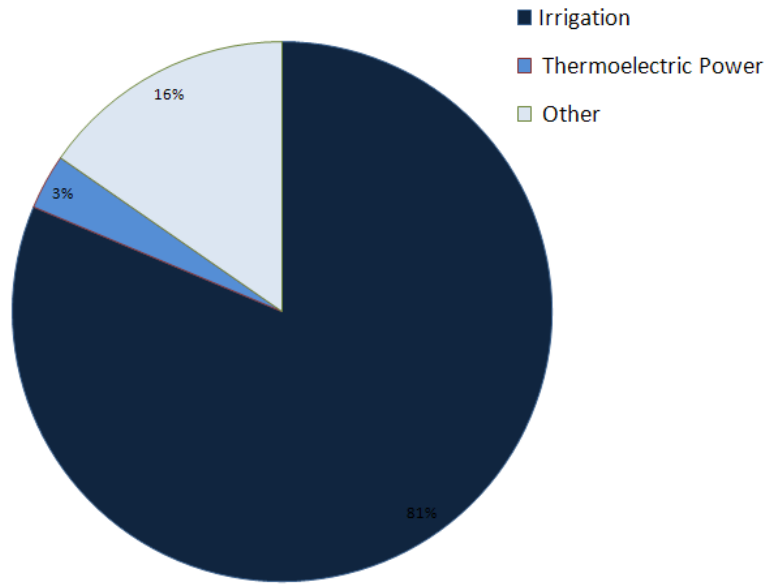
Figure 1: Total Water Withdrawals in the U.S. by Category⁵⁷



56. *Id.*

57. S.S. HUTSON, ET. AL., ESTIMATED USE OF WATER IN THE UNITED STATES IN 2000 (USGS Circular 1268, 2004), available at <http://pubs.usgs.gov/circ/2004/circ1268/>.

Figure 2: Total Water Consumption in the U.S. by Category⁵⁸



58. *Id.*

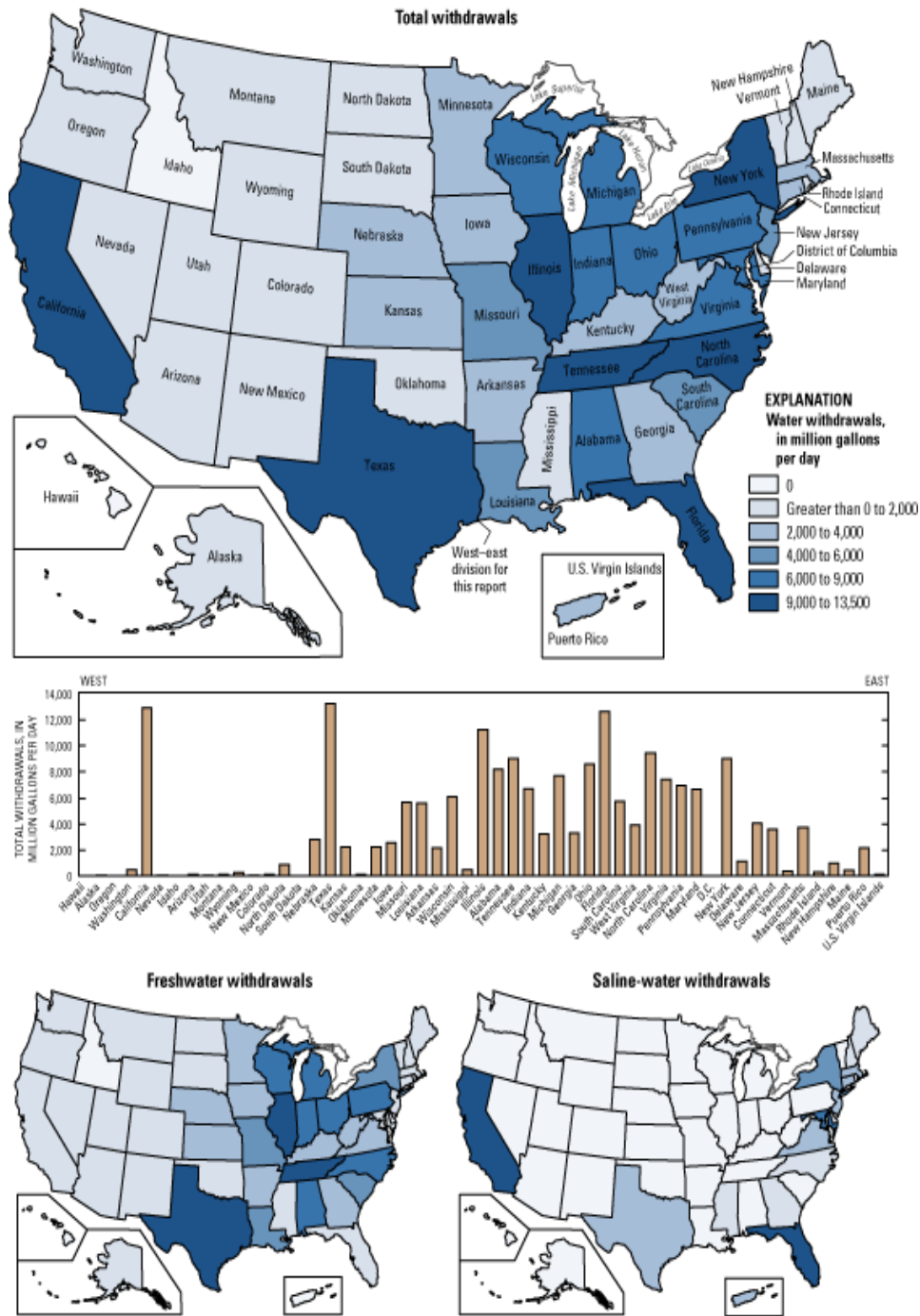
Table 1: Thermoelectric Power Water Withdrawals by State (millions of gallons/day)⁵⁹

| State | Withdrawals (in million gallons per day) | | | | | | | Withdrawals (in thousand acre-feet per year) | | |
|--------|---|---------------|--------|--------|--------|--------|--------|---|--------|--------|
| | By source and type | | | | Total | | | By type | | |
| | Grnd water | Surface water | | | Fresh | Saline | Total | Fresh | Saline | Total |
| | | Fresh | Fresh | Saline | | | | | | |
| Ala. | 0 | 8,190 | 0 | 8,190 | 8,190 | 0 | 8,190 | 9,180 | 0 | 9,180 |
| Alaska | 4.65 | 28.9 | 0 | 28.9 | 33.6 | 0 | 33.6 | 37.6 | 0 | 37.6 |
| Ariz. | 74.3 | 26.2 | 0 | 26.2 | 100 | 0 | 100 | 113 | 0 | 113 |
| Ark. | 2.92 | 2,170 | 0 | 2,170 | 2,180 | 0 | 2,180 | 2,440 | 0 | 2,440 |
| Cal. | 3.23 | 349 | 12,600 | 12,900 | 352 | 12,600 | 12,900 | 395 | 14,100 | 14,500 |
| | | | | | | | | | | |
| Colo. | 16.1 | 122 | 0 | 122 | 138 | 0 | 138 | 155 | 0 | 155 |
| Conn. | 0.08 | 186 | 3,440 | 3,630 | 187 | 3,440 | 3,630 | 209 | 3,860 | 4,070 |
| Del. | 0.47 | 366 | 738 | 1,100 | 366 | 738 | 1,100 | 411 | 827 | 1,240 |
| D.C. | 0 | 9.69 | 0 | 9.69 | 9.69 | 0 | 9.69 | 10.9 | 0 | 10.9 |
| Fla. | 29.5 | 629 | 12,000 | 12,600 | 658 | 12,000 | 12,600 | 738 | 13,400 | 14,100 |
| | | | | | | | | | | |
| Ga. | 1.03 | 3,240 | 61.7 | 3,310 | 3,250 | 61.7 | 3,310 | 3,640 | 69.2 | 3,710 |
| Haw. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Idaho | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ill. | 5.75 | 11,300 | 0 | 11,300 | 11,300 | 0 | 11,300 | 12,600 | 0 | 12,600 |
| Ind. | 2.58 | 6,700 | 0 | 6,700 | 6,700 | 0 | 6,700 | 7,510 | 0 | 7,510 |
| | | | | | | | | | | |
| Iowa | 11.9 | 2,530 | 0 | 2,530 | 2,540 | 0 | 2,540 | 2,850 | 0 | 2,850 |
| Kan. | 14.9 | 2,240 | 0 | 2,240 | 2,260 | 0 | 2,260 | 2,530 | 0 | 2,530 |
| Ky. | 2.71 | 3,250 | 0 | 3,250 | 3,260 | 0 | 3,260 | 3,650 | 0 | 3,650 |
| La. | 28.4 | 5,580 | 0 | 5,580 | 5,610 | 0 | 5,610 | 6,290 | 0 | 6,290 |
| Me. | 4.92 | 108 | 295 | 403 | 113 | 295 | 408 | 127 | 330 | 457 |
| | | | | | | | | | | |
| Md. | 1.80 | 377 | 6,260 | 6,640 | 379 | 6,260 | 6,640 | 425 | 7,020 | 7,440 |
| Mass. | 0 | 108 | 3,610 | 3,720 | 108 | 3,610 | 3,720 | 121 | 4,050 | 4,170 |
| Mich. | 0 | 7,710 | 0 | 7,710 | 7,710 | 0 | 7,710 | 8,640 | 0 | 8,640 |
| Minn. | 4.17 | 2,260 | 0 | 2,260 | 2,270 | 0 | 2,270 | 2,540 | 0 | 2,540 |
| Miss. | 43.5 | 318 | 148 | 467 | 362 | 148 | 510 | 406 | 166 | 572 |
| | | | | | | | | | | |
| Mo. | 12.2 | 5,620 | 0 | 5,620 | 5,640 | 0 | 5,640 | 6,320 | 0 | 6,320 |

59. *Id.*

| | | | | | | | | | | |
|---------------|------|---------|--------|---------|---------|--------|---------|---------|--------|---------|
| Mont. | 0 | 110 | 0 | 110 | 110 | 0 | 110 | 123 | 0 | 123 |
| Neb. | 6.87 | 2,810 | 0 | 2,810 | 2,820 | 0 | 2,820 | 3,160 | 0 | 3,160 |
| Nev. | 12.0 | 24.7 | 0 | 24.7 | 36.7 | 0 | 36.7 | 41.1 | 0 | 41.1 |
| N.H. | 0.71 | 235 | 761 | 997 | 236 | 761 | 997 | 265 | 854 | 1,120 |
| N.J. | 2.24 | 648 | 3,390 | 4,040 | 650 | 3,390 | 4,040 | 729 | 3,800 | 4,530 |
| N.M. | 11.4 | 45.0 | 0 | 45.0 | 56.4 | 0 | 56.4 | 63.2 | 0 | 63.2 |
| N.Y. | 0 | 4,040 | 5,010 | 9,050 | 4,040 | 5,010 | 9,050 | 4,530 | 5,610 | 10,100 |
| N.C. | 0.09 | 7,850 | 1,620 | 9,470 | 7,850 | 1,620 | 9,470 | 8,800 | 1,810 | 10,600 |
| N.D. | 0 | 902 | 0 | 902 | 902 | 0 | 902 | 1,010 | 0 | 1,010 |
| Ohio | 7.57 | 8,590 | 0 | 8,590 | 8,590 | 0 | 8,590 | 9,630 | 0 | 9,630 |
| Okla. | 3.27 | 143 | 0 | 143 | 146 | 0 | 146 | 164 | 0 | 164 |
| Or. | 2.47 | 12.8 | 0 | 12.8 | 15.3 | 0 | 15.3 | 17.2 | 0 | 17.2 |
| Pa. | 3.98 | 6,970 | 0 | 6,970 | 6,980 | 0 | 6,980 | 7,820 | 0 | 7,820 |
| R.I. | 0 | 2.40 | 290 | 293 | 2.40 | 290 | 293 | 2.69 | 326 | 328 |
| S.C. | 5.83 | 5,700 | 0 | 5,700 | 5,710 | 0 | 5,710 | 6,400 | 0 | 6,400 |
| S.D. | 1.23 | 4.01 | 0 | 4.01 | 5.24 | 0 | 5.24 | 5.87 | 0 | 5.87 |
| Tenn. | 0 | 9,040 | 0 | 9,040 | 9,040 | 0 | 9,040 | 10,100 | 0 | 10,100 |
| Tex. | 60.2 | 9,760 | 3,440 | 13,200 | 9,820 | 3,440 | 13,300 | 11,000 | 3,860 | 14,900 |
| Utah | 13.1 | 49.2 | 0 | 49.2 | 62.2 | 0 | 62.2 | 69.8 | 0 | 69.8 |
| Vt. | 0.66 | 355 | 0 | 355 | 355 | 0 | 355 | 398 | 0 | 398 |
| Va. | 1.50 | 3,850 | 3,580 | 7,430 | 3,850 | 3,580 | 7,430 | 4,310 | 4,020 | 8,330 |
| Wash. | 0.92 | 518 | 0 | 518 | 519 | 0 | 519 | 582 | 0 | 582 |
| W.Va. | 0 | 3,950 | 0 | 3,950 | 3,950 | 0 | 3,950 | 4,430 | 0 | 4,430 |
| Wis. | 8.99 | 6,090 | 0 | 6,090 | 6,090 | 0 | 6,090 | 6,830 | 0 | 6,830 |
| Wyo. | 1.13 | 242 | 0 | 242 | 243 | 0 | 243 | 273 | 0 | 273 |
| P.R. | 0 | 0 | 2,190 | 2,190 | 0 | 2,190 | 2,190 | 0 | 2,460 | 2,460 |
| U.S. | 0 | 0 | 136 | 136 | 0 | 136 | 136 | 0 | 153 | 153 |
| Virgin Is. | | | | | | | | | | |
| Total | 409 | 135,000 | 59,500 | 195,000 | 136,000 | 59,500 | 195,000 | 152,000 | 66,700 | 219,000 |

Figure 3: Thermoelectric Power Withdrawals by Water Quality and State⁶⁰



60. *Id.*

Such immense water needs produce equally immense concerns given the likelihood of future droughts and shortages, especially during the summer months. Even under normal conditions, water managers in thirty-six states anticipate shortages in the next ten years.⁶¹ Similarly, using a historical database of droughts going back to 1895, the U.S. Geologic Survey has predicted that almost one-fourth of the country will risk severe droughts by 2040.⁶² The most severely hit part of the country will be the West. As early as 2025, the U.S. Department of Interior cautions that “demands for water in many basins of the West exceed the available supply even in normal years.”⁶³ Given the intensity of the existing electricity industry’s water needs, if it grows as predicted, it will directly trade off with the water available for drinking, industry, and agriculture. Utilizing data from the U.S. Census Bureau, U.S. Energy Information Administration, U.S. Geologic Survey and National Oceanic and Atmospheric Administration, it appears that these tradeoffs will become most severe in twenty large metropolitan areas.⁶⁴ These regions of the country expect to add at least 2,700 MW of thermoelectric capacity and will experience population growth of at least 500 people per square mile. Thus, these regions will face water shortages of at least 1.52 inches in the summer by 2025 (See Table 2).⁶⁵

61. UNITED STATES GOV’T. ACCOUNTABILITY OFFICE, FRESHWATER SUPPLY: STATES’ VIEWS OF HOW FEDERAL AGENCIES COULD HELP THEM MEET THE CHALLENGES OF EXPECTED SHORTAGES (2003).

62. Bill Smith et al., “Water and Sustainability—The EPRI Research Plan,” *Presentation to the Water & Sustainability Workshop*, Washington, DC, July 25, 2002, p. 7.

63. STATEMENT OF ASSISTANT SEC’Y BENNET RALEY DEPT. OF INTERIOR, SENATE ENERGY AND NATURAL RES. COMM. OVERSIGHT HEARING (2004).

64. Sovacool & Sovacool, *supra* note 37. More specifically, 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/>. Data for power plant capacity additions were collected from the U.S. Energy Information Administration Form EIA-860, available from 2001 to 2006 at <http://www.eia.doe.gov/cneaf/electricity/page/eia860.html>. And estimates of the anticipated summer water deficit were taken from Sujoy B. Roy, Karen V. Summers, and Robert A. Goldstein, *Water Sustainability in the U.S. and Cooling Water Requirements for Power Generation*, WATER RESOURCES UPDATE 94-99 (2003) .

65. *Id.*

Table 2: The 20 Metropolitan Areas in the United States Most at Risk to Water Shortages Resulting from Thermoelectric Power Plants, 2025⁶⁶

| Rank | County | State | Total electricity in 2025 (in MW) | pop growth 1995 to 2025 (per sq mile) | Summer water deficit in 2025 (inches) | Metropolitan area |
|------|--------------|-------|-----------------------------------|---------------------------------------|---------------------------------------|----------------------------------|
| 1 | Mecklenburg | NC | 17,950 | 1,528 | 28.72 | Charlotte, NC |
| 2 | Lake | IL | 12,987 | 1,064 | 18.10 | Chicago, IL |
| 3 | Will | IL | 27,399 | 806 | 16.67 | Chicago, IL |
| 4 | Queens | NY | 11,613 | 8,056 | 12.68 | New York, NY |
| 5 | Cobb | GA | 3,480 | 2,049 | 9.34 | Atlanta, GA |
| 6 | Dallas | TX | 6,170 | 1,437 | 6.60 | Dallas, TX |
| 7 | Coweta | GA | 6,180 | 510 | 5.56 | Atlanta, GA |
| 8 | Denver | CO | 4,503 | 1925 | 4.98 | Denver, CO |
| 9 | Montgomery | MD | 3,776 | 757 | 4.45 | Washington, DC and Baltimore, MD |
| 10 | St. Charles | MO | 3,350 | 533 | 4.33 | St. Louis, MO |
| 11 | Washington | MN | 3,203 | 632 | 4.20 | St. Paul, MN |
| 12 | Bexar | TX | 9,222 | 555 | 2.98 | San Antonio, TX |
| 13 | Calvert | MD | 12,938 | 533 | 2.92 | Washington, DC and Baltimore, MD |
| 14 | Harris | TX | 4,462 | 1,179 | 2.40 | Houston, TX |
| 15 | Tarrant | TX | 2,704 | 1,170 | 2.34 | Dallas, TX |
| 16 | Multnomah | OR | 5,402 | 548 | 2.24 | Portland, OR |
| 17 | Contra Costa | CA | 4,759 | 678 | 1.99 | San Francisco, CA |
| 18 | Fort Bend | TX | 19,656 | 851 | 1.88 | Houston, TX |
| 19 | Wake | NC | 5,967 | 1,266 | 1.65 | Raleigh, NC |
| 20 | Suffolk | MA | 5,062 | 1,184 | 1.65 | Boston, MA |
| 21 | Clark | NV | 20,148 | 642 | 1.52 | Las Vegas, NV |
| 22 | Montgomery | TX | 2,871 | 647 | 1.52 | Houston, TX |

66. *Id.*

PART II: ELECTRICITY-WATER CHALLENGES IN EIGHT METROPOLITAN AREAS

To better illustrate many of the challenges facing electric utilities and water planners in these metropolitan areas, this section explores eight of them in detail: Atlanta, Charlotte, Chicago, Denver, Houston, Las Vegas, New York, and San Francisco. These eight regions plan to add a collective 129,828 MW of thermoelectric capacity between 2000 and 2025, power stations that would use 25.6 *trillion* gallons of water per year (or more than seventy billion gallons of water per day).⁶⁷ The dynamics of the water needs and consequences for each region will differ greatly. In some regions, such as Colorado, Georgia, and North Carolina, greater water use from power plants in 2025 could compete with the water needed for drinking, industrial manufacturing centers, and commercial enterprises. Water withdraws and consumption for power plants in Illinois and Nevada could deplete water from Lake Michigan and Lake Mead (respectively,) violating international law. In California and New York, greater power plant additions could compromise the stability of fisheries and accelerate the extinction of endangered species.

Atlanta, Georgia

In the Atlanta metropolitan area, Georgia Power, a subsidiary of Southern Company, intends to add 3,480 MW of thermoelectric capacity between 2000 and 2025.⁶⁸ Georgia Power currently services 1.13 million customers in the Metro Atlanta region, yet their 16,000 MW portfolio is heavily water-intensive. About seventy-five percent of their fleet is coal powered, eighteen percent nuclear powered, six percent oil and gas powered, and one percent from hydroelectric sources.⁶⁹ Indeed, more water will be lost as steam from Georgia Power's two nuclear plants than used by all residents of downtown Atlanta, Augusta, and Savannah combined.⁷⁰ Within the state as a whole, thermoelectric plants use slightly more than half of all surface water, which then reduce drinking water supplies by reducing flows to Lake Lanier.

The most immediate consequence of increased thermoelectric water use in Atlanta will be tradeoffs with other major industrial and commercial water users in the region. These include Georgia-Pacific Corporation (one of the world's largest manufacturers of tissue, packaging, paper, pulp and building products), Mohawk Industries (the world's largest producer of flooring and carpets), and the city's water utility. The top commercial Atlanta customers for water

67. *Id.* This projection presumes that these units would operate at a ninety percent capacity factor, and the average water use would amount to twenty-five gallons per kWh, resulting in a total water use of 25,599,348,000,000 gallons per year, or 70,135,200,000 billion gallons per day. New thermoelectric power plants were presumed to operate 24 hours a day, 365 days per year, and the water for these power plants was also assumed to have been "used" within the county.

68. *Id.*

69. GEORGIA POWER, FACTS AND FIGURES, 2008, available at <http://www.georgiapower.com/about/facts.asp>.

70. SARA BARCZAK & C. RONALD CARROLL, CLIMATE CHANGE IMPLICATIONS FOR GEORGIA'S WATER RESOURCES AND ENERGY FUTURE, PROCEEDINGS OF THE 2007 GEORGIA WATER RESOURCES CONFERENCE 2-3 (2007).

included plants operated by the Coca-Cola Corporation, Pepsi Cola Corporation, Lockheed Martin Corporation, and Edwards Baking Corporation. Pepsi's Gatorade plant, for instance, uses about five million gallons of water every month.⁷¹

State policymakers seem to recognize the danger of water shortages, and a fierce legal battle has erupted. Georgia is fighting to hold back more water along its river basins and reservoirs, but Florida and Alabama argue that Georgia has mismanaged water resources and that extra Georgian withdrawals would dry up river flows that support out of state power plants, farms, fisheries, and industrial users.⁷² Alabama, for example, says that restrictions on water use in Georgia would impede electricity production at their Farley Nuclear Plant, also on the Chathoochee River, threatening power outages among 800,000 residents in three states.⁷³ Tri-state water negotiations have so far only precipitated into eight active lawsuits, and Georgia's state assembly passed a resolution calling on the governor to set up a commission looking into having the border redrawn through the middle of Chattanooga, Tennessee. Resolutions were later introduced in both the state House and Senate to annex part of Tennessee to increase Georgia's access to water. The mayor of Chattanooga, who would lose half his city if Georgia's border was redrawn, sent a consignment of water bottles to Georgia lawmakers. He publicly announced it was better to "offer a cool, wet kiss of friendship rather than face a hot, angry legislator gone mad with thirst."⁷⁴

Charlotte, North Carolina

In Charlotte, Duke Energy Corporation reported plans to add 17,950 MW of thermoelectric capacity between 2000 and 2025.⁷⁵ Duke Energy, the primary electric utility, relies on more than 28,000 MW of electricity capacity to meet the needs of 3.9 million citizens of Ohio, Kentucky, Indiana, North Carolina, and South Carolina (the Carolinas account for 2.3 million of its customers).⁷⁶ Of its total capacity, thirty-nine percent is coal-fired, thirty-seven percent is nuclear, thirteen percent is hydroelectric, and eleven percent oil and natural gas—meaning that their entire portfolio is water-intensive. Duke already announced in March 2008 that it needed to import 520 MW of power outside of the region to ensure continuation of service during a prolonged drought.⁷⁷ One town in North Carolina was so dry that water had to be imported by fire truck.⁷⁸ In 2008, the Summer nuclear plant (near Columbia) was at such a "critical point" that

71. Ryan Mahoney, *Perdue Orders Businesses, Utilities to Cut Water Use*, ATLANTA BUSINESS CHRONICLE, October 23, 2007.

72. Ben Evans, *Feds to States: We'll Settle Water Dispute*, ASSOCIATED PRESS, March 2, 2008.

73. Ken Silverstein, *Sinking Water and Rising Tensions*, ENERGYBIZ INSIDER, December 5, 2007.

74. *Water Rows in the South: Take Them to the River*, THE ECONOMIST, March 15, 2008, at 53.

75. Sovacool & Sovacool, *supra* note 37.

76. Duke Energy Corp., FRANCHISED ELECTRIC UTILITIES, available at <http://www.duke-energy.com/power-plants/franchised.asp?sec=subnav>.

77. Duke Energy, DUKE ENERGY CAROLINAS ANNOUNCES SPECIAL POWER PURCHASE AND SEEKS COST RECOVERY, 2008.

78. Douglas Jehl, *Development and a Drought Cut Carolinas' Water Supply*, THE NEW YORK TIMES, August 29, 2002, available at <http://query.nytimes.com/gst/fullpage.html?res=9501E0DA173FF93AA1575BC0A9649C8B63>.

operators openly discussed having to shut it down for lack of water. The Harris nuclear reactor near Raleigh obtains water from Harris Lake, which was a scant 3.5 feet above the limit that the plant could operate.⁷⁹

Most of Duke's power plants draw their cooling water from the Santee River Watershed, which includes the Catawba-Wateree River, a water source that has earned the title "America's Most Endangered River for 2008."⁸⁰ This "Most Endangered River" basin, however, is about the only place to situate new thermoelectric power plants, and the associated water use with these capacity additions could exacerbate drought (at best) and risk interstate litigation and agricultural collapse (at worst). Low water levels along the river leave bottom-dwelling organisms such as clams and mussels stranded, and tend to induce algal blooms that contaminate water supplies. Low water levels also degrade drinking water infrastructure, since they diminish revenues for water utilities (meaning they have less earnings available for maintenance,) and dry and crack soil leading to pipeline malfunctions and spills.⁸¹

Chicago, Illinois

In Chicago, electric utility planners intend to add 40,386 MW between 2000 and 2025.⁸² Chicago is formally served by Commercial Edison, a subsidiary of Exelon Corporation. Exelon, one of the largest electric utility providers in the nation, serves 5.2 customers, but under a \$4.8 billion deal sold many of its power plants to Midwest Generation (which generates electricity but only sells it on the wholesale market).⁸³ Commercial Edison, now the nation's largest supplier of nuclear power (and the world's third largest supplier), operates one of the most water-intensive fleets in the electricity industry.⁸⁴ The total amount of thermoelectric power generation in the area is about 12,649 MW, drawing mostly from a mix of local rivers, Lake Michigan, and Powerton Lake.

The most immediate impact to future thermoelectric withdrawals from Lake Michigan could be a violation of domestic and international law. The Supreme Court decided in 1996 that the State of Illinois had to limit its diversion and use of water from Lake Michigan.⁸⁵ Under the ruling, Illinois must legally reduce its water usage over the next fourteen years—not increase it for power plants.⁸⁶ Furthermore, since the Great Lakes contain twenty percent of the world's freshwater supply and ninety-five percent of the freshwater for the United States,

79. Mitch Weiss, *Drought Could Force Nuke-Plant Shutdowns*, SAN FRANCISCO CHRONICLE, January 24, 2008.

80. Environmental News Service, AMERICA'S 10 MOST ENDANGERED RIVERS (2008), available at <http://www.ens-newswire.com/ens/apr2008/2008-04-17-01.asp>.

81. Catawba Riverkeeper, ALERT: 2007 DROUGHT ADVISORIES (2007), available at <http://www.catawbariverkeeper.org/News/News/alert-2007-drought-advisory/>.

82. Sovacool & Sovacool, *supra* note 37.

83. Exelon Corp., ABOUT US, available at <http://www.exeloncorp.com/aboutus/>.

84. *Id.*

85. Council of Great Lakes Governors, GREAT LAKES WATER MANAGEMENT INITIATIVE, available at <http://www.cglg.org/projects/water/legal.asp> (presenting a list of all international treaties, legal agreements, and federal and state laws pertaining to the Great Lakes Watershed).

86. Michigan Dept. of Environmental Quality, LAKE MICHIGAN DIVERS AN SUPREME COURT DECREE, available at <http://www.deq.state.mi.us/documents/deq-ogl-diversions-decreesummary.pdf>.

they are strenuously protected under international law.⁸⁷ The 1909 International Boundary Waters Treaty, signed between Canada and the United States, specifically governs water resource use on Lake Michigan.⁸⁸ The most recent agreements, signed by all Great Lakes State Governors and Canada's Provincial Premiers in December 2005,⁸⁹ recognize that "the Waters of the Basin are a shared public treasure and the States and Provinces as stewards have a shared duty to protect, conserve and manage these renewable but finite Waters."⁹⁰ Thus, deploying more thermoelectric power plants could defy domestic court rulings and international treaties.

Denver, Colorado

In the Denver metropolitan area, Xcel Energy may build 4,503 MW of thermoelectric capacity between 2000 and 2025.⁹¹ Xcel operates three power generating facilities in Denver—the Cherokee, Zuni, and Arapahoe Plants—all which use water from the South Platte River.⁹² Located south of downtown, the Arapahoe Station is a 156 MW coal-fired plant that uses about 586 million gallons of water annually from the South Platte River.⁹³ The Zuni Station, closer to downtown, is a 107 MW natural gas plant that uses 98 million gallons of water annually from the South Platte River.⁹⁴ The Cherokee Station, north of downtown, is a 717 MW coal-fired plant that uses 2.4 billion gallons of water from the South Platte River annually (along with about 5,200 acre-feet of recycled water from Denver Water's Reuse Water Plant).⁹⁵

Because the South Platte River is the primary water source for the region, increased power plant withdrawals and consumption could seriously deplete the water needed for households and businesses (about forty-seven percent of Denver's water is used by single family homes).⁹⁶ Water use from any additional power plants would have to be balanced against the needs of the many downstream users along the South Platte. A severe shortage could risk economic and environmental impoverishment, since the municipal drinking water system in Eastern Colorado and farming and ranching activities in Nebraska rely on the river.⁹⁷

87. Great Lakes Directory, *available at* http://www.greatlakesdirectory.org/great_lakes_water_export.htm.

88.

89. States include Illinois, Indiana, Michigan, Minnesota, New York, Ohio, and Wisconsin; the Commonwealth of Pennsylvania; and the Canadian Provinces of Ontario and Québec.

90. The Council of Great Lakes Governors, GREAT LAKES-ST. LAWRENCE RIVER BASIN SUSTAINABLE WATER RESOURCES AGREEMENT, (2005).

91. Sovacool & Sovacool, *supra* note 37.

92. Joey Bunch, *Water-guzzling Power Plants Targeted By Legislation*, DENVER POST, February 03, 2004.

93. *Id.*

94. *Id.*

95. *Id.*

96. *Id.*

97. USGS National Water Quality Assessment Program, SOUTH PLATTE RIVER BASIN, 2008, *available at* <http://co.water.usgs.gov/nawqa/splt/>.

Houston, Texas

In Houston, electricity demand could grow to need 26,989 MW of new thermoelectric capacity by 2025.⁹⁸ The situation with retail electricity access in the Houston area is more complicated than many other cities (although the construction and dispatch of generation remain roughly the same). In June 1999, Texas Senate Bill SB 7 made retail electric competition state law and phased-in “retail choice” of electricity on January 1, 2002.⁹⁹ The legislation forced incumbent Texan utilities such as TXU and Reliant Energy to restructure their assets into separate retail marketing, generation, transmission, and distribution companies.¹⁰⁰ The bill attempted to lower prices and limited the market power of existing suppliers by unbundling transmission, distribution, and generation; it also prohibited any single utility from owning more than fifteen percent of generation within a service region.¹⁰¹

Thus, the electricity market serving Houston is complex. More than 200 different electricity plans are available to Houston residents and service is offered from sixty-eight competitive retailers, including eight large utilities—Champion Energy, CPL Retail Energy, Direct Energy, Gexa Energy, Green Mountain Energy, Reliant Energy, Spark Energy, and TXU Energy—that generate and distribute power from five distinct zones all over the state.¹⁰² Taken together, these power providers operate about 95,400 MW of capacity, forty-eight percent fueled by natural gas, thirty-nine percent by coal, eleven percent from nuclear, and three percent from “other” sources.¹⁰³ The largest of these is the “wires only” utility CenterPoint Energy, which maintains the T&D infrastructure serving 5,000 square miles around the city (although it does not generate a single kWh of power).¹⁰⁴ CenterPoint serves two million customers in Houston and operated 3,600 miles of transmission lines, 226 substations, twelve service centers, and 43,000 miles of distribution lines to deliver 75.9 billion kWh in 2006.¹⁰⁵

Increasing the number of power plants in the Houston vicinity, however, could reduce the water needed for drinking and agriculture. In the past, Houston depended primarily on groundwater to meet eighty percent of its supply, but rapid depletion has lowered that amount to only sixty-seven percent today, forcing the city to take more water from the Trinity, San Leon, and San Jacinto Rivers (along with the reservoirs they support). With Houston water planners predicting rising demands for drinking water, there may not be enough water for

98. Sovacool & Sovacool, *supra* note 37.

99. United States Energy Information Administration, STATUS OF STATE ELECTRIC INDUSTRY RESTRUCTURING ACTIVITY, (2003), *available at* http://www.eia.doe.gov/cneaf/electricity/chg_str/restructure.pdf.

100. *Id.*

101. *Id.*

102. Joel Mickey, ERCOT OPERATION’S PERSPECTIVE ON LESSONS LEARNED (2004).

103. United States Energy Info. Admin., TEXAS NUCLEAR INDUSTRY (2006), *available at* http://www.eia.doe.gov/cneaf/nuclear/page/at_a_glance/states/statestx.html.

104. CenterPoint Energy, WHERE WE SERVE (2008), *available at* <http://www.centerpointenergy.com/about/companyoverview/whereweserve/>.

105. *Id.*

new power plants.¹⁰⁶ Surface water upstream from Houston is also needed to irrigate agriculture. During the last serious water shortage caused by a prolonged drought in 1996, the agricultural sector was the first to suffer as water was diverted to supply power plants and drinking water systems.¹⁰⁷

Las Vegas, Nevada

Population is growing so quickly in Nevada that more than 20,000 MW of thermoelectric capacity may be built in Las Vegas between 2000 and 2025.¹⁰⁸ Because of the rapid growth in population, Nevada Power Company, the primary electric utility, is also one of the fastest growing utilities in the country. Nevada Power's service area covers 807,000 customers spread across 4,500 square miles in southern Nevada, including the cities of Las Vegas, North Las Vegas, and Henderson.¹⁰⁹ It operates 35,990 miles of T&D lines and has invested \$5.4 billion in about 5,623 MW of mostly natural gas and coal-fired power plants, which it uses to meet 54.3 percent of the region's power needs.¹¹⁰ The shortfall is made up from purchased power imported from Arizona, Utah, and other parts of the state.¹¹¹

The water needs for this portfolio of power technologies is significant. Nevada Power's fleet of plants currently use water from a combination of local reservoirs, underground aquifers and wells, and the Colorado River, with a significant amount coming from the beleaguered Lake Mead. According to water use profiles reported by the Nevada Division of Environmental Protection, the 465 MW El Dorado gas power plant uses 176,100 gallons of water per day from Lake Mead.¹¹² The almost completed Copper Mountain Power Plant, a 660 MW natural gas plant soon to be operating in Clark County, will use 75,000 gallons of potable water per day from Lake Mead.¹¹³ The Reid Gardner Station, a four-unit 650 MW coal fired power plant in the Moapa Valley, uses groundwater that would otherwise replenish Lake Mead. The power plant consumes about 286,000 gallons of water per day from the Muddy River (which flows into Lake Mead), but has also contaminated local aquifers and wells.¹¹⁴ The Reid Gardner station's cooling ponds and waste landfills have leaked sulfates and toxic pollutants into the watershed. Groundwater underlying the power plant has become so contaminated that it exceeds federal safety standards

106. Natural Resources Defense Council, *WHAT'S ON TAP? GRADING DRINKING WATER IN U.S. CITIES* (2003).

107. D.A. Wilhite & O. Vanyarkho, *Drought: Pervasive Impacts of a Creeping Phenomenon*, IN *DROUGHT: A GLOBAL ASSESSMENT* (D.A. Wilhite ed., 1996).

108. Sovacool & Sovacool, *supra* note 37.

109. NEVADA POWER, *ANNUAL REPORT TO THE SECURITIES AND EXCHANGE COMMISSION FOR DECEMBER 31, 2006*, (2007).

110. *Id.*

111. *Id.*

112. NEVADA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES AND NEVADA DIVISION OF ENVIRONMENTAL PROTECTION, *NEVADA POWER GENERATION FACILITIES 1*(2006).

113. *Id.*

114. Robert J. Saunders, *NEVADA DIVISION OF ENVIRONMENTAL PROTECTION FACT SHEET* (2005).

for no less than twelve criteria pollutants including arsenic, chromium, lead, and selenium.¹¹⁵

If more thermoelectric power plants are built as planned, the most immediate impact would be greater water shortages for the Las Vegas Valley Water District and further reductions in Lake Mead, which is already experiencing and “extreme hydrological drought.”¹¹⁶ Researchers from the Federal Bureau of Land Reclamation estimate that the Lake Mead water system is losing 326 billion gallons of water per year, or enough to supply eight million people, a loss so significant it can be seen by satellite images from space.¹¹⁷ If new power plants further tap Lake Mead, the result could be a full blown agricultural disaster. Lake Mead directly irrigates about a million acres of farmland in southern California’s Imperial Valley, “and another half million acres in northern Mexico as part of [an] international water treaty.”¹¹⁸

New York, New York

Planned thermoelectric capacity additions for New York could surpass 11,600 MW by 2025.¹¹⁹ The major electric utility directly serving New York City is Consolidated Edison, which provides electric service to most of the City (excluding a small part of Queens) and Westchester County. The utility operates about 1,739 MW of its own capacity (mostly oil and gas plants) to supply 10.5 percent of its power, but imports the rest from competitive suppliers through an integrated bulk power system known as the New York Control Area.¹²⁰ About half electricity generated within the city comes from power plants in Queens County, and a majority of this power comes from the 2,450 MW Ravenswood natural gas power plant on the East River.¹²¹ Consolidated Edison takes its generated and purchased power and delivers it to about three million customers through 94,000 miles of underground electric cables—the largest underground system in the world and enough cable to wrap around the Earth more than three times.¹²²

The water needs for the portfolio of power generators that must supply power within Consolidated Edison and the New York Control Area are substantial, but they do not tradeoff directly with the City’s water supply. The City’s water comes from nineteen reservoirs, three controlled lakes, and about 300 miles of aqueducts spanning the Catskill Mountains to Westchester

115. *Id.*

116. NASA, LAKE MEAD WATER LEVEL DROPS, 2000 TO 2004 (2004), http://www.nasa.gov/vision/earth/lookingatearth/Lake_Mead2004.html.

117. Alexis Madrigal, *Fifty Percent Change Lake Mead Will be Dry By 2021, Models Show*, WIRED (February 13, 2008), available at <http://blog.wired.com/wiredscience/2008/02/this-is-what-wa.html>.

118. Jesse Allen, *Drought Lowers Lake Mead*, NASA, November 13, 2003, available at <http://earthobservatory.nasa.gov/Features/LakeMead/>.

119. Sovacool & Sovacool, *supra* note 37.

120. NEW YORK INDEPENDENT SYSTEM OPERATOR, COMPREHENSIVE RELIABILITY PLANNING PROCESS DRAFT RELIABILITY NEEDS ASSESSMENT (2005), available at http://www.nyiso.com/public/webdocs/documents/newsletters/nyiso_insider/insider_093005.pdf.

121. NEW YORK CITY ENERGY POLICY TASK FORCE, NEW YORK CITY ENERGY POLICY: AN ELECTRICITY RESOURCE ROADMAP (2004).

122. CONSOLIDATED EDISON, CON EDISON 2007 ANNUAL REPORT (2008).

County.¹²³ Instead, new power plant additions would likely consume and withdraw water from the Hudson River, where seven facilities constituting 6,691 MW of capacity—Bethlehem Energy Center (previously the Albany Steam Station), Danskammer Generating Station, Roseton Power Plant, Indian Point Energy Center, Lovett Power Plant, Bowline Power Plant, and the IRT Power Plant on 59th Street—already use 6.1 billion gallons of water directly from the Hudson for coolant every day.¹²⁴

New power plants could consequently have a devastating impact on local fisheries and ecosystems through the discharge of heated effluent, entrainment, and impingement. A series of extensive fishery surveys along the Hudson, including the Long River Survey (assessing egg and larval densities), Fall Shoals Survey (assessing densities of juvenile fish populations), and the Beach Seine Survey (assessing the abundance of fish communities) determined that thermoelectric power plants were devastating freshwater fisheries in the early 1970s.¹²⁵ The federal government passed extensive regulations to limit the damage, but utility restructuring this past decade has renewed concern that electric utilities, more focused on competition, will be less focused on environmental compliance. Indeed, one 2006 study has already warned that additional thermoelectric power additions along the Hudson could increase mortality of Striped Bass (already weakened from current power plants), bay anchovy (already suffering fifty percent year class reductions due to power plants), and Atlantic Tomcod (at stress due to any further increases in water temperature).¹²⁶ A similar 2007 study warned that the withdrawal of cooling water for new thermoelectric plants would have:

“profound . . . impacts on aquatic environments” [including] “reductions of phytoplankton, zooplankton, fish, and shellfish, including the loss of threatened and endangered species; damage to aquatic organisms, including important elements of the food chain; reduction of populations and their compensatory reserves; losses of commercial and recreational fisheries; and stresses to overall communities and ecosystems.”¹²⁷

San Francisco, California

In San Francisco, electricity demand could grow to justify the construction of 4,759 MW of thermoelectric capacity between 2000 and 2025.¹²⁸ Both competitive power producers and electric utilities operate in the San Francisco Bay Area. The Mirant Corporation, an independent power producer, operates

123. The Croton Storage system alone can transfer ninety million gallons a day, and the Catskill System can store another 140.5 billion gallons of water and supplies about forty percent of the daily drinking water needs of the City. The Delaware System stores another 320.4 billion gallons of water. N. Y. CITY OF DEPT. OF ENVTL. PROT., WHERE DOES MY WATER COME FROM? (2008), available at http://www.nyc.gov/html/dep/html/water_and_sewer_bills/wsbillfaq.shtml#A1.

124. JEFFREY S. LEVINTON AND JOHN R. WALDMAN, THE HUDSON RIVER ESTUARY Table 14.1 at 198 (2006).

125. *Id.* at 198-201.

126. *Id.*

127. Stephen L. Kass, et al., *Power Plant Cooling water, Hudson River Fish—Again*, N. Y. L. J. (February 23, 2007) available at <http://www.clm.com/publication.cfm/ID/118>.

128. Sovacool & Sovacool, *supra* note 37.

the 674 MW Contra Costa natural gas plant, the 1,311 MW Pittsburg natural gas plant (both situated near the confluence of the Sacramento and San Joaquin Rivers), and the 362 MW Potrero natural gas plant (which uses cooling water directly from the San Francisco Bay).¹²⁹ Pacific Gas and Electric Company (PG&E) also operates the 530 MW natural gas-fired Gateway Generating Station near Antioch. The plant receives its water from the Delta at the confluence of the Sacramento and San Joaquin Rivers. PG&E's 2,200 MW Diablo Canyon Nuclear Power Plant, located in Avila Beach, uses water from the Pacific Ocean.

Given the region's unique hydrology, the immediate effect of additional water use from new thermoelectric power plants could be drought, shortages of drinking water, and species extinction. Most of power plants in the Bay Area draw water from the Sacramento-San Joaquin Delta, a massive, natural, inverted river delta, where numerous waterways converge downstream, eventually flowing into the Suisun Bay and the Upper San Francisco Bay (where they proceed to flow into the Pacific Ocean under the Golden Gate Bridge).¹³⁰ The same water system replenishing the rest of California, therefore, is the one that power plants predominately use. The water system is instrumental in distributing water to twenty-five million Californians extending beyond San Francisco through the Central Coast to Los Angeles and San Diego.¹³¹ About 2.5 million acres of productive farmland rely on the Sacramento-San Joaquin Delta for irrigation, and the California Draught Preparedness Organization has already warned that water supplies are running dangerously low.¹³² Further contributing to a shortage of water, a 2007 District Court ruling protecting the endangered Delta Smelt effectively cut California's drinking and water irrigation supplies by thirty-five percent.¹³³ Almost one month after the court decision, the Coalition for a Sustainable Delta filed a lawsuit against the Mirant Corporation, alleging that their Contra Costa and Pittsburg natural gas power plants harmed the Delta Smelt by using more than a billion gallons of water a day to cool steam turbines.¹³⁴ In April 2008, further restrictions on water withdrawals were implemented out of concerns that rapid declines in Delta water were harming the Sacramento River Chinook Salmon.¹³⁵ New conventional power plant additions, it appears, could risk possible species extinction in addition to drought and water shortages.

129. MIRANT CORPORATION, CONTRA COSTA GENERATING PLANT (2009), available at http://www.mirant.com/our_business/where_we_work/index.html#CA.

130. CAL. DEPT. OF WATER RES., CAL. STATE WATER PROJECT (2009), available at <http://www.water.ca.gov/swp/>.

131. CAL. DRAUGHT PREPAREDNESS, WATER SHORTAGES (2009), available at <http://www.cadroughtprep.net/watshort.htm>.

132. *Id.*

133. Peter Fimrite, *Ruling to protect Delta Smelt may force water rationing in Bay Area*, SAN FRANCISCO CHRONICLE, September 1, 2007, at A1, available at <http://www.mindfully.org/Water/2007/Delta-Smelt-Rationing1sep07.htm>.

134. *Id.*

135. Dan Bacher, *Federal Judge Tosses California Plan to Export More Delta Water*, CALIFORNIA PROGRESS REPORT, April 17, 2008, available at http://www.californiaprogressreport.com/2008/04/federal_judge_t.html.

PART III: RECOMMENDATIONS FOR ELECTRIC UTILITIES AND REGULATORS

What can regulators in these cities and states, along with the eight utilities most at risk (Georgia Power, Duke Energy, Commercial Edison, Xcel Energy, CenterPoint, Nevada Power Company, Consolidated Edison, and Pacific Gas & Electric Company) and the dozens of others possibly like them, do in the face of these electricity-water challenges? While many disputes over water in the West and Southeast are interstate, local regulators and electric utilities are still exceptionally positioned to respond to such risks within their jurisdiction. City and state regulators are often much more attuned to the needs and dynamics of their constituents than federal policymakers, and can respond more quickly and efficiently to local problems.¹³⁶ Electric utilities serve as direct intermediaries between electricity consumers and power providers and generators; have established supply, metering, and billing relationships with their customers; are more flexible than government agencies and can quickly tailor programs; and possess the most knowledge about electricity production and use in their area.

This section argues that while a cornucopia of different technologies and mechanisms are available to regulators and electricity utilities, a combination of six could be very effective at avoiding future water shortages: increasing research and development funding for alternative power plant cooling cycles, placing a moratorium on thermoelectric power generation, strongly promoting energy efficiency and demand-side management, rapidly deploying wind turbines and solar photovoltaic panels, changing electricity prices and giving electricity customers more feedback and information, and asking the federal government (or forming interstate organizations) to designate select regions of the country “Electricity-Water Crisis Areas.”

Increase Funding for R&D on Alternative Cooling Cycles

The U.S. Department of Energy, through separate programs at the National Energy Technology Laboratory and Sandia National Laboratory, has begun to look into making conventional power plants more water-efficient, and a number of emerging technologies can greatly reduce water use. Researchers working at these programs, for example, have investigated treating and reusing “impaired,” “nonpotable,” “produced,” “brackish,” “reclaimed,” or “gray” water to cool power plants.¹³⁷ The most common applications include using secondary treated municipal waste water, passively treated coal mine drainage, and ash pond effluent. Fifty-seven power plants, mostly in the arid Western part of the United States, already rely on cooling cycles that utilize reclaimed water, and while abundant sources of reclaimed water are available in Alaska, California, Kansas, Louisiana, Oklahoma, Texas, and Wyoming (accounting for 90.1 percent of

136. Benjamin K. Sovacool, *The Best of Both Worlds: Environmental Federalism and the Need for Federal Action on Renewable Energy and Climate Change*, 27.2 STAN. ENVTL. L.J. 397-476, 429-441 (June, 2008) (arguing in favor of a “decentralized” mode of environmental policymaking).

137. NETL and Sandia, *supra* notes 30 and 31.

produced water), it would be a prohibitively costly for forty-three states.¹³⁸ Of the produced water in these seven states, only thirty-seven percent is of the quality needed to run in power plants.¹³⁹

Another option being explored is enabling power plants to produce some of their own water, either through capturing water vapor from flu 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 which can be recovered from flu gas using liquid desiccant-based absorption systems or modified electrostatic precipitators. Engineers at NETL expect that such capture technologies could reduce five percent of evaporative water loss at power plants.¹⁴⁰ Diffusion driven desalination, a process that uses the excess waste heat from power plants to produce distilled water, can also minimize the water needs of power plants situated in coastal areas.¹⁴¹

Thermoelectric power plants, in other words, need not always consume and withdraw water as they do today, and opportunities exist to substantially improve the efficiency of thermoelectric cooling cycles. While none of the technologies discussed here are yet available at a commercial scale, doubling or tripling the funding for the research programs at Sandia and NETL could provide the technological breakthroughs needed to greatly reduce water use at power plants in the future.

Place a Moratorium on New Thermoelectric Power Generation

Perhaps the simplest response electric utilities can take is to stop building new thermoelectric generation in areas where water shortages are expected to occur, or water prices anticipated to rise rapidly. As the two next sections suggest, existing thermoelectric and hydroelectric capacity would be sufficient to meet existing power needs but energy efficiency, wind, and solar could offset any expected increases in electricity demand. Using these three tools to offset thermoelectric capacity additions is important because drought and flood are a normal, recurring part of the North American hydrologic cycle. 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

138. UNITED STATES DOE OFFICE OF SCIENTIFIC & TECHNICAL INFO., 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 (2005) available at <http://www.osti.gov/energycitations/servlets/purl/841466-0LRrRo/native/841466.pdf>.

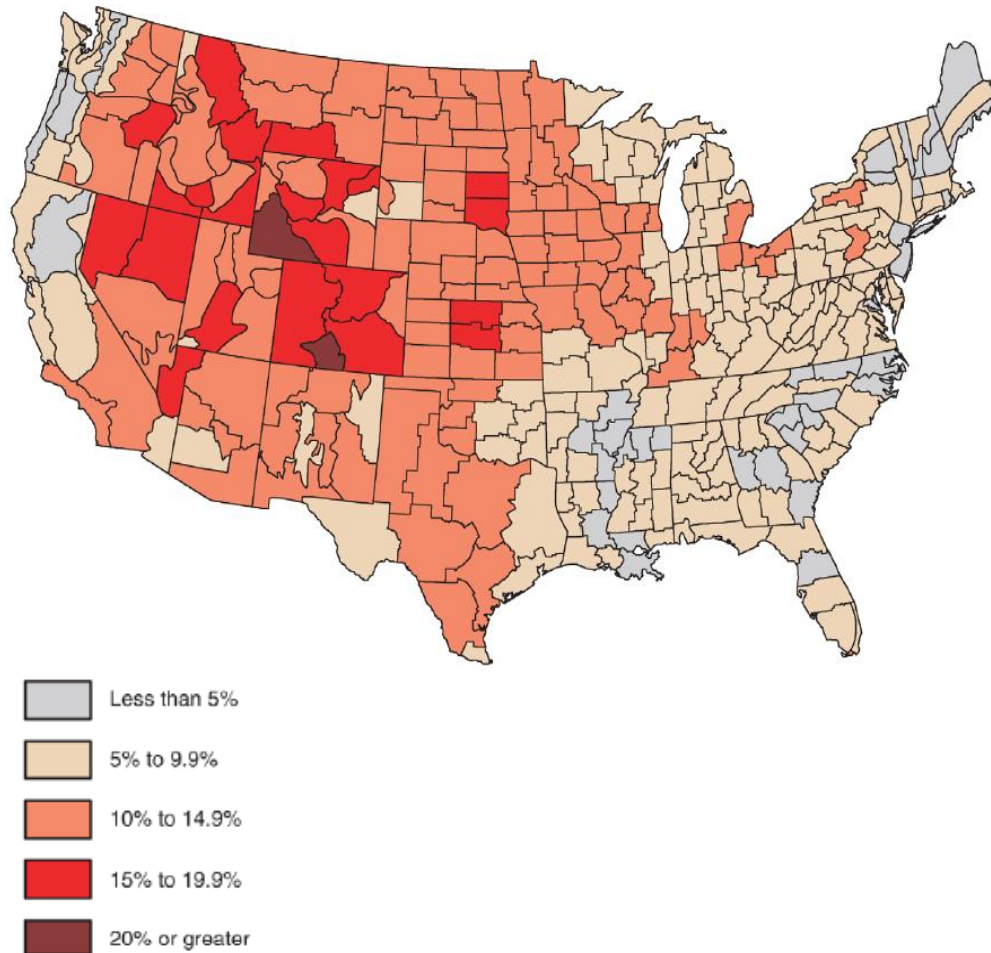
139. *Id.*

140. UNITED STATES DEP'T OF ENERGY OFFICE OF FOSSIL ENERGY NAT'L ENERGY TECH. LAB., REDUCTION OF WATER USE IN WET FGD (2006), available at http://www.netl.doe.gov/publications/proceedings/05/UCR_HBCU/pdf/papers/Klausner.pdf.

141. JAMES F. KLAUSNER & RENWEI MEI, INNOVATIVE FRESH WATER PRODUCTION PROCESS FOR FOSSIL FUEL PLANTS: ANNUAL REPORT (2005), available at <http://www.osti.gov/bridge/servlets/purl/835262-XjApqw/native/835262.pdf>.

the time.¹⁴² Given the likelihood of future water shortages, utilities could justify transitioning away from water intensive thermoelectric generation (See Figure 4).

Figure 4: Percent of Time in Severe and Extreme Drought Nationwide, 1895 to 1995¹⁴³



The addition of new conventional power plants therefore has two inherent water-related risks that suggest electric utilities should no longer construct them: they are unable to withdrawal water needed for normal operation in times of scarcity, and can cause and worsen existing water shortages when their fuel cycles consume water. Thermoelectric power plants running on coal, natural gas, oil, and uranium require immense amounts of water to cool the combustion

142. UNITED STATES DEPARTMENT OF INTERIOR, SPECTER OF INEVITABLE DROUGHT, THE ARID WEST—WHERE WATER IS SCARCE (2006).

143. DONALD WILHITE, IMPROVING DROUGHT MANAGEMENT IN THE WEST: THE ROLE OF MITIGATION AND PREPAREDNESS 6-8 (1997) (report to the Western Water Policy Review Advisory Commission) available at <http://www.drought.unl.edu/pubs/wwprcw.pdf>.

process. They withdraw trillions of gallons of water from our rivers and streams. They consume billions of gallons of water from local aquifers and lakes. A moratorium would therefore offer a very effective tool for preserving water resources.

One possible objection to a moratorium would be that future increases in electricity demand can only be reliably met by fossil-fueled and nuclear base-load power plants. While this concern is a legitimate one, the next two sections show that the promotion of energy efficiency, demand side management, and improved feedback to electricity customers could offset the need to build any new thermoelectric capacity.

Furthermore, attaching wind turbines to pumped hydro and compressed air energy storage systems can improve their capacity factor to above seventy percent, making them “functionally equivalent to a conventional baseload . . . plant.”¹⁴⁴ Paul Denholm found that generating base-load power from a hybrid wind/compressed air energy storage system would add only about 0.7 ¢/kWh to its cost of producing electricity, and that converting natural gas plants to biomass generators to backup wind farms would add only about 0.2 ¢/kWh, two relatively inexpensive options to create completely renewable base-load units.¹⁴⁵ Contrary to some proclamations stating otherwise, “[a] baseload wind system,” notes Denholm, “can produce a stable, reliable output that can replace a conventional fossil or nuclear baseload plant.”¹⁴⁶ Similarly, Vasilis Fthenakis and his colleagues from Brookhaven National Laboratory, the Renewable Energy Research Institute, and the Institute for Analysis of Solar Energy recently concluded that with new advances in compressed air energy storage make it “clearly feasible to replace the present fossil fuel energy infrastructure in the [United States] with . . . renewables.”¹⁴⁷ Researchers at the Georgia Institute of Technology and the Virginia Polytechnic Institute & State University even found that when coupled with a rigorous energy efficiency and demand management program, solar panels could completely displace the electricity currently coming from the two GW Indian Point nuclear facilities in New York at a cost less than building a new nuclear power plant.¹⁴⁸

Promote Energy Efficiency and Demand-Side Management

To offset the risks of placing a moratorium on future thermoelectric generators, electric utilities should rigorously implement energy efficiency and demand-side management programs (DSM). Curiously, such action would not

144. Paul Denholm et al., *Emissions and Energy Efficiency Assessment of Baseload Wind Energy Systems*, 39 ENV'T'L SCIENCE & TECH. 1903, 1911 (2005).

145. Paul Denholm, *Improving the Technical, Environmental and Social Performance of Wind Energy Systems Using Biomass-Based Energy Storage*, 31 RENEWABLE ENERGY 1356 (2006), available at <http://www.nrel.gov/docs/fy06osti/38270.pdf>.

146. *Id.* at 1.

147. Vasilis Fthenakis et al., *The Technical, Geographical, and Economic Feasibility for Solar Energy to Supply the Energy Needs of the U.S.*, 37 ENERGY POLICY 387-399 (2009).

148. Marilyn A. Brown & Benjamin K. Sovacool, *Promoting a Level Playing Field for Energy Options: Electricity Alternatives and the Case of the Indian Point Energy Center*, 1(1) ENERGY EFFICIENCY 35-48 (2008).

only help address impending electricity related water shortages, but would also improve energy security, lower electricity and water prices, and enhance reliability. For the historical record suggests that energy efficiency, DSM, and load management practices represent the most feasible way of responding to increases in electricity demand. Increasing energy efficiency, one study concluded, “is generally the largest, least expensive, most benign, most quickly deployable, least visible, least understood, and most neglected way to provide energy services.”¹⁴⁹ Or, as Jon Wellinghoff, the Commissioner of the FERC, put it, “the potential benefits from the incorporation of demand response into wholesale markets indicate that a considerable margin of gain is possible from accelerating such activity.”¹⁵⁰

The Department of Energy (DOE) recently calculated the benefits of DSM and found that it lowers wholesale electricity prices as costly power plants are displaced and total demand on the system decreases. Generating peak electricity is extremely expensive, often exceeding \$5,000 to \$10,000 per installed kW (meaning a 100 MW plant can cost \$750 million to build and require seventy-five million dollars per year to operate), implying that DSM should be profitable for *all* utilities.¹⁵¹ Eric Hirst estimated the costs and benefits of DSM programs for three types of utilities: a “surplus” utility, an “average” utility, and a “deficit” utility.¹⁵² Surplus utilities are those with excess capacity and few planned retirements, as well as slow projected growth in fossil fuel prices and incomes.”¹⁵³ Deficit utilities have little excess capacity, many planned retirements, and rapid growth in prices and incomes.¹⁵⁴ Average utilities fall in the middle. Hirst found in each case that DSM programs raise electricity prices but reduce electricity costs, and the overall percentage reduction in cost far exceeds the increase in price.¹⁵⁵ He found 2-to-1 cost benefits for the surplus utility (i.e., every dollar spent on DSM yielded two dollars of savings), 5-to-1 cost benefits for the average utility, and 8-to-1 cost benefits for the deficit utility.¹⁵⁶ In other words, energy efficiency may cause electricity prices (per kWh) to go up slightly, but because people and companies use fewer kWhs, their bills actually go down. For some utilities, cost savings can be as high as eight dollars for every one dollar invested in DSM.

For these reasons, a few states have experimented with large-scale DSM programs. In the state of New York, cost-effective DSM and load management policies have saved more than 1,000 gigawatt hours (GWh) of electricity and displaced 880 MW of peak demand in the past five years.¹⁵⁷ Montana, Idaho, and Oregon conserved energy totaling more than 50,000 GWh per year in the

149. AMORY B. LOVINS, ENERGY END-USE EFFICIENCY 1 (2005).

150. John Wellinghoff & David L. Morenoff, *Recognizing the Importance of Demand Response: The Second Half of the Wholesale Electric Market Equation*, 28 ENERGY L.J. 389, 396 (2007).

151. U.S. DEPT. OF ENERGY, BENEFITS OF DEMAND RESPONSE IN ELECTRICITY MARKETS AND RECOMMENDATIONS FOR ACHIEVING THEM (2006).

152. *Id.* at 99.

153. Eric Hirst, *Price and Cost Impacts of Utility DSM Programs*, 13 THE ENERGY J. 75 (1992).

154. *Id.*

155. *Id.*

156. *Id.* at 87.

157. NEW YORK STATE ENERGY RESEARCH & DEV. AUTHORITY, N. Y. ENERGY SMART PROGRAM EVALUATION AND STATUS REPORT 2, Table 1 (2004).

mid-1990s with a retail value of two billion dollars to consumers.¹⁵⁸ California's DSM programs operating between 1990 and 1992 delivered 112 percent of planned energy savings, meaning they cost-effectively saved *more* than electricity than intended.¹⁵⁹ The Massachusetts Department of Energy Resources discovered their load management program lowered participants' electricity costs by twenty million dollars in 1999, with benefits to Massachusetts customers exceeding six million dollars in just thirteen hours on one high-cost day.¹⁶⁰

Notwithstanding these impressive gains, there is much more potential in energy efficiency and DSM than some ever imagined. The National Association of Regulatory Utility Commissioners (NARUC) found cost-effective energy efficiency potential in *all* regions of the country, with the most untapped potential in the Northeast and South, where electricity costs are highest (meaning energy efficiency efforts are more economical than areas where energy is cheaper).¹⁶¹ Another study projected that cost-effective energy efficiency programs could reduce consumption by around one trillion kWh by 2020, offsetting almost all projected growth in electricity use—and the needed capacity additions to achieve it.¹⁶² The Alliance to Save Energy found that aggressive investments in energy efficiency could free up enough electricity to eliminate the need to construct more than 1,300 power plants in the next twenty years.¹⁶³ One study projected that a national DSM program aimed at reducing peak demand by just five percent would yield three billion dollars in net generation, transmission, and distribution savings per year and displace some 625 infrequently used peaking plants and associated delivery infrastructure.¹⁶⁴

Other broader studies confirm DSM's cost-effectiveness. The International Energy Agency reviewed forty large-scale commercial DSM programs found that they saved electricity at an average cost of 2.1 to 3.0 ¢/kWh.¹⁶⁵ Similarly, the Institute of Electrical and Electronics Engineers found an average cost of 2.6 ¢/kWh for demand-side management, load management, and energy efficiency programs in Vermont.¹⁶⁶ When thinking about these numbers, readers are asked

158. Ralph Cavanagh, *Restructuring for Sustainability: Toward New Electric Service Industries*, ELECTRICITY JOURNAL 72 (1996).

159. MARILYN A. BROWN & PHILLIP E. MIHLMESTER, WHAT HAS DSM ACHIEVED IN CALIFORNIA? PROCEEDINGS OF THE 7TH NATIONAL DEMAND-SIDE MANAGEMENT CONFERENCE 229-235 (1995).

160. RICHARD COWART, EFFICIENT RELIABILITY: THE CRITICAL ROLE OF DEMAND-SIDE RESOURCES IN POWER SYSTEMS AND MARKETS 64 (2001) [hereinafter Cowart]. The effectiveness of the same program was also noted by Mark D. Levine and Richard Sonnenblick, *On The Assessment of Utility Demand-Side Management Programs*, 22 ENERGY POLICY 848 (1994) available at http://econpapers.repec.org/article/eeeene/pol/v_3A22_3Ay_3A1994_3Ai_3A10_3Ap_3A848-856.htm. On p. 848, the authors note that the DSM program enabled "society ... to purchase US\$21 million of avoided kilowatt hours at a cost of US\$14 million, a highly cost-effective investment."

161. Cowart, *supra* note 154.

162. Antonio Herzog et al., *Renewable Energy: A Viable Choice*, 43 ENVIRONMENT 13 (2001).

163. DAVID M. NEMTZOW, "NATIONAL ENERGY POLICY: CONSERVATION AND ENERGY EFFICIENCY," HEARING BEFORE THE HOUSE COMMITTEE ON ENERGY AND COMMERCE 76-81, (2001).

164. Ahmad Faruqui et al., *The Power of 5 Percent*, 20 ELECTRICITY JOURNAL 68-77 (2007).

165. HOWARD GELLER & SOPHIE ATTALI, THE EXPERIENCE WITH ENERGY EFFICIENCY POLICIES AND PROGRAMS IN IEA COUNTRIES: LEARNING FROM THE CRITICS (2005).

166. Susan Chang, *The Rise of the Energy Efficiency Utility*, IEEE SPECTRUM, May, 2008, available at <http://spectrum.ieee.org/print/6216>.

to consider that one kWh saved is more valuable than one kWh generated. One thousand MW of energy efficiency and 1,000 MW of large-scale generation are not equivalent. Richard Cowart found that every dollar invested in energy efficiency:

- Mitigated against uncertainty and lowered load, wear, and maintenance needs on the entire fossil fuel chain, even in hours when reliability problems were not anticipated by system managers;
- Depressed the costs of locally used fuels such as oil, coal, and natural gas;
- Reduced demand across peak hours, the most expensive times to produce power;
- Lessened costly pollutants and emissions from generators;
- Improved the reliability of existing generators;
- Moderated transmission congestion problems;
- Operated automatically through customers coincident with the use of underlying equipment or load, meaning they are always “on” without delay or the needed intervention by system operators to schedule or purchase the resource.¹⁶⁷

Discounting all of these benefits and looking purely at reductions in peak demand, the New York ISO determines a reserve criterion of eighteen percent during times of peak demand to ensure overall system reliability.¹⁶⁸ Accordingly, each 1.0 MWh of peak demand that customers avoid through energy efficiency means that utilities can subtract 1.18 MWh of total capacity needed. Quite literally, every single kWh of peak electricity avoided through energy efficiency equates to 1.18 kWh of avoided supply.¹⁶⁹ While this calculation would not necessarily hold true for the displacement of base-load generators, since most peaking power plants rely on natural gas the water savings could still be substantial. Natural gas units are the third most water-intensive of all power plants, using about fourteen gallons of water per kWh (second to coal at thirty-six gallons per kWh and nuclear power at forty-three gallons per kWh).¹⁷⁰

Furthermore, a majority of energy efficiency savings can be accomplished with small and targeted programs. In the ISO-New England service area, for example, about nine percent of the system’s total generating capacity is tapped one percent of the time. The price of power during this most expensive one percent accounts for sixteen percent of the total annual dollars spent on the spot

167. Cowart, *supra* note 154.

168. Memorandum from Mark Reeder, Steve Keller and Tom Paynter, State of N.Y. Dept. of Pub. Serv. To John Charlton and David Lawrence, NYISO (June 4, 2004) *available at* http://www.nyiso.com/public/webdocs/committees/bic_icapwg/meeting_materials/2004-08-02/dps_comments_regarding_levitanreport.pdf.

169. CHARLES KOMANOFF, SECURING POWER THROUGH ENERGY CONSERVATION AND EFFICIENCY IN NEW YORK: PROFITING FROM CALIFORNIA’S EXPERIENCE, *Report for the Pace Law School Energy Project and the Natural Resources Defense Council* (May, 2002), pp. 1-22.

170. Sovacool & Sovacool, *supra* note 37.

market.¹⁷¹ These numbers reveal that a very small fraction of supply accounts for a large fraction of total cost. Nationwide, Cowart calculated that just 0.4 percent of industrial customers account for thirty percent of total demand.¹⁷² Consequently, relatively small DSM programs directed at a miniscule proportion of the nation's electricity customers can produce mammoth benefits in terms of total demand reductions.

Finally, a significant amount of energy efficiency and DSM potential exists in the eight metropolitan areas identified above. Georgia Power could cut projected load by thirty-three percent for residential and commercial customers (and twenty-six percent for industrial customers) by 2018.¹⁷³ The same study found an achievable potential for energy efficiency programs—that is, energy that could be saved if existing programs were funded to their full potential—of 2,509 GWh per year. Another assessment conducted by the Governor's office estimated that twenty-three to twenty-four percent of cumulative load growth could be displaced by cost-effective energy efficiency programs (amounting to the equivalent of about 1,771 MW of displaced capacity).¹⁷⁴ In North Carolina, Duke Energy has acknowledged that their "save-a-watt" program could displace 1,318 MW of peak capacity by 2012 if properly funded.¹⁷⁵ Similarly, Lawrence Berkeley National Laboratory researchers estimated that Chicago had at least 3,456 MW of untapped DSM potential.¹⁷⁶ Environment Illinois, a nonprofit group, concluded that home weatherization programs, enforcement of energy star appliance standards, and light bulb replacements could cost-effectively save the state more than 2,100 GWh, displace the need for fourteen billion cubic feet of natural gas, and cut home energy use by twenty percent.¹⁷⁷ If coupled with more aggressive retrofitting schemes and other investments, household energy consumption would be reduced by forty percent (and with technological improvements, ninety percent).¹⁷⁸

In Colorado, Xcel Energy admitted that it could ramp up its DSM program to provide an additional 200 GWh (equivalent to eighty MW of peak potential) if properly incentivized.¹⁷⁹ An independent report from KEMA found that the state of Colorado at large had at least 2,031 MW of technical energy efficiency

171. Cowart, *supra* note 154.

172. *Id.*

173. JESS CHANDLER, SOUTHEASTERN STATES ELECTRIC EFFICIENCY POTENTIAL: META-ANALYSIS OF POTENTIAL STUDIES (2007), *available at* <http://www.spp.gatech.edu/faculty/WOPRpapers/Chandler%5B1%5D.WOPR.pdf>.

174. GOVERNOR'S ENERGY POLICY COUNCIL, STAFF RESEARCH BRIEF: MEETING FUTURE ELECTRICITY DEMAND (2007).

175. FRANK R. ELLERBE, APPLICATION OF DUKE ENERGY CAROLINAS, LLC FOR APPROVAL OF DECISION TO INCUR NUCLEAR GENERATION PRE-CONSTRUCTION COSTS (2007).

176. Data Taken from Table EX 1 of S. Konopacki & H. Akbari, *Energy Savings for Heat Island Reduction Strategies in Chicago and Houston (Including Updates for Baton Rouge, Sacramento, and Salt Lake City)* (Lawrence Berkeley National Laboratory, February, 2002).

177. ENVIRONMENT ILLINOIS, THE POWER OF EFFICIENCY: OPPORTUNITIES TO SAVE MONEY, REDUCE POLLUTION AND EXPAND THE ECONOMY IN THE MIDWEST (2008).

178. *Id.*

179. DEB SUNDIN, XCEL ENERGY'S COLORADO ENERGY EFFICIENCY PLAN, PRESENTATION TO THE CEU EXCHANGE CONFERENCE (2007).

potential.¹⁸⁰ Texas has 40,000 MW of energy efficiency potential characterized by demand response, solar PV, and improved building codes, appliance standards, and public energy efficiency initiatives.¹⁸¹ These alternative sources could meet 107 percent of the projected growth in summer peak demand by 2013 and displace thirty-three percent of peak load by 2023.¹⁸² A DSM program in Texas would not only displace conventional generation, but would also result in utility bill savings of seventy-three billion dollars at an avoided cost of 4.5¢/kWh, much cheaper than the state-average retail electric price of 9.1¢/kWh. And, in Nevada, fully funding just nine energy efficiency programs could displace the need to construct 5,571 MW of capacity in the Sierra Pacific and Nevada Power service areas by 2020.¹⁸³

In New York, the National Research Council, along with a study led by researchers at the Georgia Institute of Technology, found a significant amount of programmable energy efficiency potential within New York City.¹⁸⁴ That is, existing programs would only need to be properly funded to achieve roughly 4,461 GWh of potential by 2012. Both studies show that residential energy efficiency improvements in lighting, cooling, refrigeration, electronics, space heating, and hot water heating, along with commercial improvements in lighting, refrigeration, cooling, ventilation, office equipment, water heating, space heating, and building controls, could cost-effectively displace the need to build 550 MW of peak capacity by 2015.¹⁸⁵ The studies estimated that an additional 300 MW of peak capacity could be displaced by aggressive demand response programs.¹⁸⁶ The Natural Resources Defense Council and Pace University Law School Energy Center (now the Pace Energy & Climate Center) estimated even greater potential in the New York City area, and concluded that savings of up to 3,032 MW peak demand could be achieved by aggressive energy efficiency programs within two years.¹⁸⁷ Finally, the San Francisco Bay Area Economic Forum calculated that scaling up load management programs in the region could displace 2,500 additional MW of thermoelectric capacity.¹⁸⁸

180. KEMA INC., COLORADO DSM MARKET POTENTIAL (2006).

181. NEAL ELLIOTT, ET. AL, POTENTIAL FOR ENERGY EFFICIENCY, DEMAND RESPONSE, AND ONSITE RENEWABLE ENERGY TO MEET TEXAS'S GROWING ELECTRICITY NEEDS (2007).

182. *Id.*

183. *Id.* at X.

184. Marilyn A. Brown & Benjamin K. Sovacool, *Promoting a Level Playing Field for Energy Options: Electricity Alternatives and the Case of the Indian Point Energy Center*, 1 ENERGY EFFICIENCY 35 (2008) [hereinafter Brown & Sovacool]; and NATIONAL RESEARCH COUNCIL, ALTERNATIVES TO THE INDIAN POINT ENERGY CENTER FOR MEETING NEW YORK ELECTRIC POWER NEEDS 283-298 (2006), available at http://www.nap.edu/catalog.php?record_id=11666.

185. *Id.*

186. *Id.*

187. Komanoff, *supra* note 162.

188. Bay Area Economic Forum, *Lightning Strikes Twice: California Faces the Real Risk of a Second Power Crisis* (August, 2004).

Deploy Wind Farms and Solar Photovoltaic (PV) Panels

In situations where energy efficiency and DSM programs are unable to completely offset the need to construct new thermoelectric power plants, utilities could rely on wind turbines and solar panels to produce electricity. These two technologies use almost no water to generate electricity, and need only a very small amount for cleaning and maintenance.¹⁸⁹ Even more remarkably, looking at the marginal levelized cost of building power plants in 2009—that is, the cost of constructing, operating, maintaining, and fueling a new facility—offshore and onshore wind turbines produce electricity for between 2.6 and 5.6 ¢/kWh, making them two of the six cheapest sources of power.¹⁹⁰ Solar PV is the most expensive at 39 ¢/kWh, but not far behind expensive peaking plants that cost between 32.5 and 35.6 ¢/kWh to operate.¹⁹¹ Wind, in other words, is already cheap, and solar (which is getting cheaper) is nearing parity with natural gas peaking facilities.

Nationally, commercially available wind and solar photovoltaic power generators could provide almost 3,000 GW of capacity—roughly three times the country's existing capacity—by 2010 if only they were built.¹⁹² (Building these wind and solar power facilities would also have the additional benefit of providing high-paying manufacturing jobs in those regions of the country hardest hit by the financial crisis).¹⁹³ Again, while the following estimates and projections should be taken in context, the eight metropolitan regions discussed in Part II have substantial amounts of wind and solar potential¹⁹⁴.

In Georgia, solar PV systems could provide at least 104 MW of cost-effective peaking power by 2010.¹⁹⁵ In Atlanta, 13,223 MW of peak capacity could be displaced by placing solar arrays on just commercial and residential

189. Sovacool & Sovacool, *supra* note 37.

190. Benjamin K. Sovacool, *Renewable Energy: Economically Sound, Politically Difficult*, 21 ELEC. J. 24 (2008) [hereinafter Sovacool].

191. *Id.*

192. BENJAMIN K. SOVACOO, THE DIRTY ENERGY DILEMMA: WHAT'S BLOCKING CLEAN POWER IN THE UNITED STATES 95 at Table 5 (2008).

193. Sovacool, *supra* note 180, pp. 107-108 (the Renewable Energy Policy Project used North American Industrial Classification Codes to map the dispersion of manufacturing activity related to the development of wind energy. They found that expansion of the domestic wind industry could create 831,499 jobs in twenty states, and that those states receiving the most investment and most new manufacturing jobs would account for seventy-five percent of the total United States population, and seventy-six percent of the manufacturing jobs lost in the United States between 2001 and 2004).

194. When discussing this potential, the following section does not mention getting the power to the market or the necessity of building transmission and distribution systems and developing interconnection standards. This is because projections provided by the Energy Information Administration (EIA) concerning conventional thermoelectric capacity additions also exclude these factors (and the author wanted to compare apples with apples). This means that the EIA has reported only what utilities told them what power plants they intend to construct, not what may actually get constructed. Moreover, the projections elucidated by 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. Thus, when this section talks about the potential for wind and solar power resources it focuses mostly on technical potential as well so that accurate comparisons can be made.

195. Governor's Energy Policy Council, *supra* note 167.

buildings.¹⁹⁶ Moreover, certified wind maps project more than 10,000 MW of offshore wind power could be imported to Atlanta.¹⁹⁷

In North Carolina, an independent consulting team found 9,600 MW of onshore wind potential, with a “practical” amount of 1,500 MW, that could be installed in Duke Energy’s service territory to produce 3,900 GWh of electricity per year.¹⁹⁸ Indeed, researchers at Stanford University and the University of Delaware projected that offshore wind energy near the Mid-Atlantic coast could supply 330,000 MW of power—enough to meet the energy needs of nine states from Massachusetts to North Carolina (including D.C.) with electricity left over to support a fifty percent increase in demand.¹⁹⁹

In Chicago, the DOE confirmed that Illinois and the region surrounding the city had at least 9,000 MW of potential onshore wind power at only five of the state’s prime sites. These areas represent about 1.2 percent of state land and each square kilometer of windy land could support about five MW of installed wind capacity.²⁰⁰ Offshore wind potential in Lake Michigan is even greater. A report partially funded by the Wisconsin Focus on Energy Program, after sampling hundreds of wind sites and assessing lake depth, concluded that the mid-lake plateau would be “excellent” for offshore wind farms with steady and strong winds, and that the Lake has energy potential “in excess of 10,000 MW.”²⁰¹ The estimate was confirmed by an independent and interdisciplinary analysis of potential offshore sites which found that 9,700 MW could be developed.²⁰²

Colorado’s combination of high mountains and flat plains creates a bounty of wind resources, with strong and consistent winds coursing through the western part of the state and Denver. The Governor’s Energy Office has noted that a significant amount of this wind—about 93,000 MW—could be converted into electricity.²⁰³ The DOE found more potential, and noted that the state has about 170,000 MW of potential wind capacity (with the capability to produce 288 billion kWh of electricity per year), even when making exclusions for land use and environmental permits.²⁰⁴ The Hewlett Foundation also projected that

196. PAUL DENHOLM, SUMMARY OF ROOFTOP SOLAR PV AND HOT WATER RESOURCE AVAILABILITY FOR GEORGIA (2006).

197. SARA BARCZAK, PUBLIC COMMENTS FROM THE SOUTHERN ALLIANCE FOR CLEAN ENERGY, U.S. NUCLEAR REGULATORY COMMISSION PUBLIC MEETING ON THE DRAFT EIS FOR THE VOGTLE EARLY SITE PERMIT 3 (2007); and GEORGIA WIND WORKING GROUP/AWS TRUEWIND, *available at* <http://www.gawwg.org/windresources/georgiawindresourceemap.html>.

198. JONATHAN WINER, MON-FEN HONG, & DICK SPELLMAN, RENEWABLE PORTFOLIO STANDARD ANALYSIS FOR THE STATE OF NORTH CAROLINA (2006).

199. TRACEY BRYANT, MID-ATLANTIC OFFSHORE WIND POTENTIAL: 330 GW (2007).

200. UNITED STATES DEPT. OF ENERGY, ILLINOIS WIND MAPS (2001), *available at* http://www.eere.energy.gov/windandhydro/windpoweringamerica/where_is_wind_illinois.asp.

201. ROBERT H. OWEN, FINAL REPORT TO WISCONSIN FOCUS ON ENERGY ON LAKE MICHIGAN OFFSHORE WIND RESOURCE ASSESSMENT (2004).

202. JOHN S. HINGTGEN, OFFSHORE WIND FARMS IN THE WESTERN GREAT LAKES: AN INTERDISCIPLINARY ANALYSIS OF THEIR POTENTIAL (2003).

203. MOREY WOLFSON, A SUMMARY OF THE SB07-091 TASK FORCE REPORT ON RENEWABLE RESOURCE GENERATION DEVELOPMENT AREAS TO THE COLORADO CLEAN ENERGY DEVELOPMENT AUTHORITY (2007).

204. UNITED STATES DEPT. OF ENERGY, COLORADO: WIND POWERING AMERICA (2000), *available at* <http://www.nrel.gov/docs/fy00osti/28083.pdf>.

eighty-three million MWh per year of solar PV resources could be deployed within the state, or about twice as much electricity as consumed state-wide.²⁰⁵

Three of the five largest wind farms in the nation are located in Texas: the state holds the record for the world's largest wind farm (the 736 MW Horse Hollow Wind Energy Center), and it is the site for the nation's second-largest wind farm (the 505 MW Sweetwater Wind Project).²⁰⁶ The potential, nonetheless, has hardly been exhausted, and the Texas Public Utility Commission estimates that as much as 25,000 MW of wind power could flow to urban centers by 2012.²⁰⁷ The Union of Concerned Scientists projects that the state could add another 17,800 MW of wind by 2025.²⁰⁸

In Nevada, after assessing land use patterns and favorable wind sites, researchers discovered a large concentration of achievable wind energy near Las Vegas. The University of Nevada calculated that state had the potential for more than fifty million MWh of wind power, or the equivalent of 3,240 MW of installed capacity in the three counties surrounding Las Vegas.²⁰⁹ Solar PV resources for Southern Nevada are excellent: about 7,000 to 7,500 watts hours per square meter, making Las Vegas "one of the best sources for this type of generation in the world."²¹⁰ Researchers at the Hewlett Foundation and the Energy Foundation projected that the tri-county area surrounding Las Vegas could provide 11,700 MW of power from solar PV systems.²¹¹

New York City has an equally impressive amount of building integrated solar PV potential. Researchers at the Center for Sustainable Energy at Bronx Community College projected that solar PV systems mounted on rooftops and building façades could supply eighteen percent of the city's electricity by 2022. Each square foot of New York City receives the equivalent of 160 kWh of sunlight per year, enough commercial and residential roof space to host between 8,500 MW and 15,700 MW of PV installations.²¹² Researchers at the University

205. HEWLETT FOUNDATION AND THE ENERGY FOUNDATION, COLORADO RENEWABLE ENERGY RESOURCES, RENEWABLE ENERGY ATLAS OF THE WEST 35-38 (2008).

206. TEXAS STATE ENERGY CONSERVATION OFFICE, TEXAS WIND ENERGY (2008), *available at* http://www.seco.cpa.state.tx.us/re_wind.htm.

207. *Id.*

208. UNION OF CONCERNED SCIENTISTS, INCREASING THE TEXAS RENEWABLE ENERGY STANDARD 3 (2005).

209. MARY RIDDEL & R. KEITH SCHWER, THE POTENTIAL ECONOMIC IMPACT OF NEVADA'S RENEWABLE ENERGY RESOURCES (2003), *available at* <http://energy.state.nv.us/taskforce/Renewables%20%20Report%20Final.doc> (more specifically, the study noted full utilization of Nevada's wind resources could generate 50,589,000 megawatt hours (mWh) of electricity, or 3,161,812.5 MWh per county. Presuming that wind turbines operate at a capacity factor of thirty-three percent, 1,080 MW of power would be needed per county).

210. *Id.*

211. HEWLETT FOUNDATION & THE ENERGY FOUNDATION, RENEWABLE ENERGY ATLAS OF THE WEST (2008), *available at* <http://www.energyatlas.org/> (the study noted that solar PV potential for the state was about ninety-three million MWh/yr. Given that there are sixteen counties and this potential is spread evenly throughout the state, this amounts to about 5.81 million MWh per year per county. Using a capacity factor of seventeen percent, Clark County would need to construct 3,900 MW of solar PV to provide this power. The nearby Lincoln and Nye counties would have to add another 7,800 MW).

212. THE CENTER FOR SUSTAINABLE ENERGY AT BRONX COMMUNITY COLLEGE, NEW YORK CITY'S SOLAR ENERGY FUTURE: THE MARKET FOR PHOTOVOLTAIC SYSTEMS IN NEW YORK CITY (2006).

of Albany estimated that 2,431 MW of solar PV potential exists for the state of New York on large parking lots alone.²¹³

Lastly, the San Francisco has estimated that it has at least thirty MW of small-scale wind generation in the Bay Area.²¹⁴ The nonpartisan California Energy Commission (CEC) concluded that the Bay Area could rapidly deploy 4,000 MW of wind potential in the form of large onshore wind farms in only a few years.²¹⁵ Stanford University researchers projected that between twenty-six percent and 112 percent of California's *entire* electricity needs could be provided with offshore wind.²¹⁶ A single 2,385 MW wind farm sited on the Northern California coast, for instance, could produce about 9.7 TWh of electricity, enough to displace 5.6 percent of the state's fossil fueled generation (the authors comment that the 9.7 TWh estimate is on the low end of the potential for the Bay Area, with a high end of twenty-seven TWh).²¹⁷ Researchers at the Golden Gate University Law School estimated annual PV output for San Francisco at 550 to 1300 GWh per year. At the high end, this is comparable to current residential (and industrial) electricity use in San Francisco.²¹⁸ At the *low* end, the researchers estimated that PV output could displace 600 MW of peaking power plants. The researchers noted that over the thirty year period that they analyzed, the standard deviation of annual average solar radiation was less than 2.5 percent of its average value, suggesting that solar resources would be very reliable.²¹⁹ They also noted that these PV systems could be integrated into buildings and rooftops, meaning they would have no new requirements for land.²²⁰ The CEC analyzed the state's solar PV resources and found that since they could be deployed virtually anywhere in the state, their technical potential exceeded seventeen million MW of capacity. If applied only to existing residential and commercial rooftops, the CEC concluded solar PV potential exceeded 74,000 MW of capacity.²²¹

213. LUCAS ROOT & RICHARD PEREZ, PHOTOVOLTAIC COVERED PARKING LOT: A SURVEY OF DEPLOYABLE SPACE IN THE HUDSON RIVER VALLEY, NEW YORK CITY, AND LONG ISLAND, NEW YORK (2006), *available at* <http://asrc.cestm.albany.edu/perez/2006/parking.pdf>.

214. AMERICAN WIND ENERGY ASSOCIATION, SMALL WIND IN CAL. (2006), *available at* <http://www.awea.org/smallwind/california.html>.

215. DORA YEN-NAKAFUJI, CALIFORNIA ENERGY COMMISSION, CALIFORNIA WIND RESOURCES (2005).

216. MICHAEL J. DVORAK ET AL., CALIFORNIA OFFSHORE WIND ENERGY POTENTIAL, PROCEEDINGS FROM WINDPOWER 2007: AMERICAN WIND ENERGY ASSOCIATION WINDPOWER 2007 CONFERENCE & EXHIBITION (2007).

217. *Id.*

218. KARINA GARBESI & EMILY BARTHOLOMEW, THE POTENTIAL FOR SOLAR ELECTRICITY GENERATION IN SAN FRANCISCO, A REPORT TO THE ENVTL LAW AND JUSTICE CLINIC OF GOLDEN GATE UNIVERSITY LAW SCHOOL (2001).

219. *Id.*

220. *Id.*

221. GEORGE SIMONS & JOE MCCABE, CAL. SOLAR RES. IN SUPPORT OF THE 2005 INTEGRATED ENERGY POLICY REPORT (2005).

Change Electricity Prices and Improve Information

A moratorium on thermoelectric generation, energy efficiency and DSM programs, and wind and solar PV deployment should be supplemented with utility efforts to alter electricity prices and provide feedback and information to electricity customers. Three changes would be most significant: more accurate electricity pricing, altered electricity billing practices, and a utility-wide information program to educate consumers.

Consumers are generally unaware of daily, weekly, and seasonal changes in electricity price, and instead see only a monthly electricity bill. They thus consume electricity indiscriminately. Utility programs that reflect time-of-use through “real-time,” “interval metering,” “time-of-use”, or “seasonal” rates could show customers how electricity production and consumption varies according to the time of day, week, and month. Most electricity bills combine charges into a lump sum, making it difficult for consumers to tell how much of the bill results from the individual use of appliances or technologies, how much the bill could be decreased by using more efficient models, or how much electricity use can be shifted to off-peak times.²²²

The Energy Policy Act of 2005 (EPAcT)²²³ implicitly recognized this flaw in electricity pricing, and encouraged utilities to provide time-based rate schedules reflecting variations during the day to all individual customers requesting it. However, the EPAcT also said, ambiguously, that each state regulatory authority can decide whether to implement that provision.²²⁴ Correspondingly, Lawrence Berkeley National Laboratory estimates that only about 100 utilities (less than two percent) offered some sort of time-of-use rate for electricity customers in 2007.²²⁵

Yet a preponderance of evidence suggests that pricing electricity more accurately will greatly improve the efficiency of the electricity industry, provide customers with proper price signals, and reduce wasteful energy use. One study provided residents with daily electricity prices for a month and found a 10.5 percent reduction in electricity use.²²⁶ Another analysis of residential electricity use from 1973 to 1980 found that “feedback” in the form of information detailing daily and weekly electricity prices reduced consumption between six and twenty percent.²²⁷ When Princeton University researchers gave residents of Twin Rivers, New Jersey, information about their level of electricity and natural

222. BENJAMIN K. SOVACOO, *THE DIRTY ENERGY DILEMMA: WHAT’S BLOCKING CLEAN POWER IN THE UNITED STATES* 208 (2008).

223. Energy Policy Act of 2005, 42 U.S.C. § 15801 (2005).

224. John Dernbach, *Stabilizing and Then Reducing U.S. Energy Consumption: Legal and Policy Tools for Efficiency and Conservation*, 37 ENV’T L. R. 10026 (2007).

225. LBNL ENV’T L. ENERGY TECH. DIV., TARIFF ANALYSIS PROJECT (2007), available at <http://tariffs.lbl.gov/>.

226. Willett Kempton & Linda Layne, *The Consumer’s Energy Analysis Environment*, 22 ENERGY POLICY 857 (1994).

227. Robin C. Winkler & Richard A. Winnett, *Behavioral Interventions in Resource Conservation*, 37 AMERICAN PSYCHOLOGIST 421 (1982) 421-435.

gas use on a daily basis, consumption dropped ten to fifteen percent.²²⁸ Another study involved eight experiments tracking electricity use at 602 households over the course of many years. In some experiments, feedback was given three to four times a week, and in one experiment it was given continuously and informed households of the cost of their consumption every half hour.²²⁹ The researchers found that frequent, credible feedback about electricity prices resulted in 10-to-13 percent less electricity use than control groups.²³⁰

In two of the metropolitan areas discussed above, New York and Atlanta, electric utilities have already started altering electricity prices to change behavior. New York has experimented with “alternative rate designs” by offering time-of-use rates, day-ahead real time pricing, critical peak pricing, and pricing at real-time market rates.²³¹ Researchers at LBNL surveyed 149 commercial and industrial customers in the Niagara Mohawk Power Corporation service area where the utility offered time-of-use tariffs for large customers with peak demand needs.²³² They found that more than thirty percent of industrial customers responded by foregoing discretionary electricity usage and fifteen percent shifted usage from peak-periods to off-peak periods; forty-five percent of respondents installed demand reduction enabling technologies on site; and peak load for the utility was reduced by fifteen percent.²³³ Further south, Georgia Power introduced time-of-use meters for large industrial customers and, from 1992 to 2002, enrolled 1,650 customers to reduce peak demand by seventeen percent.²³⁴

Because most people remain uninformed about the electricity-water nexus, a second form of feedback could be useful: making water usage associated with electricity generation “visible” by including it in people’s electricity bills. California, for example, was the first state in the country to enact an Advance Recovery Fee on sales of some electronics. Whenever customers purchase new cell phones and televisions, a visible fee between six and ten dollars appears separately on receipts, showing consumers how much it will cost to collect and recycle some of the toxic elements inside their products.²³⁵ The same technique could be used in electricity billing, where consumers could be shown a separate line estimating the number of gallons of water used (and/or its associated cost) to produce the electricity they used within their home that day, week, or month.

228. C. GOLDMAN, ET. AL., CUSTOMER RESPONSE TO DAY-AHEAD WHOLESALE MARKET ELECTRICITY PRICES: CASE STUDY OF RTP PROGRAM EXPERIENCE IN NEW YORK (2004) [Hereinafter Goldman]; C. GOLDMAN ET AL., DOES REAL-TIME PRICING DELIVER DEMAND RESPONSE? A CASE STUDY OF NIAGARA MOHAWK’S LARGE CUSTOMER RTP TARIFF (2004).

229. *Id.*

230. L. J. Becker, C. Seligman, J. M. Darley, *Psychological Strategies to Reduce Energy Consumption* (Princeton: Center for Energy and Environmental Studies, 1979).

231. ERNEST ORLANDO LAWRENCE BERKELEY NAT’L LAB., CUSTOMER RESPONSE TO DAY-AHEAD MKT ELEC. PRICES: CASE STUDY OF RTP PROGRAM EXPERIENCE IN N.Y. (2004), available at <http://drrc.lbl.gov/pubs/nmpcpr-82505.pdf>.

232. Charles Goldman, *Customer Strategies for Responding to Day-Ahead Market Hourly Electricity Pricing*, DRRC (2005), available at <http://drrc.lbl.gov/pubs/nmpcpr-82505.pdf>.

233. Goldman, *supra* note 217.

234. Justin Colledge et al., *Demand Side Management: Power by the Minute*, POWER ECONOMICS, Feb. 28, 2002 (quoted in footnote 3 at <http://library.findlaw.com/2003/Mar/6/132618.html>).

235. Noah Sachs, *Planning the Funeral at the Birth: Extended Producer Responsibility in the European Union and the United States*, 30 HARV. ENVTL. L. REV. 51-98 (2006).

The last type of information that utilities can offer consumers is education. The DOE noted in 2008 that eighty-eight percent of Americans would fail even a “basic” electricity-literacy test.²³⁶ Another recent report in Kentucky found that forty-one percent of respondents identified coal, steel, and oil as “renewable resources.”²³⁷ Because they remain uninformed and misinformed about electricity, many consumers will not understand the scope and scale of the electricity industry’s water needs. Utilities could fund and promote electricity information and education campaigns to teach the public about electricity and water use. These could include grade-school classes on energy and the environment; public demonstrations and tours of renewable power facilities; free energy audits and training sessions for industrial, commercial, and residential electricity customers; and utility sponsored document “clearing houses” that offer websites, free books, and articles to help consumers gather and process information in order to make more informed choices about their electricity use.

Designate National “Electricity-Water Crisis Areas”

Finally, each of the above efforts could be complemented by state or federal designation of national “Electricity-Water Crisis Areas.”²³⁸ Cities and states expecting the most severe water shortages and thermoelectric capacity additions could form an interstate organization to monitor and manage electricity-water resources, or could approach the federal government (most likely the FERC) to establish a National Electricity Water Policy Program Office through either Congressional legislation or an Executive Order.²³⁹ This Program Office could advise and assist local and state water managers and energy policymakers in their efforts to implement the efforts described above. 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, the DOE, the Department of Agriculture, the Department of Interior, the EPA, the Office of the Federal Environmental Executive, the Council on Environmental Quality, the Federal Energy Management Program, and the U.S. Geological Survey. This Task Force would have a few benefits over state-level action, since it could have the authority to 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.²⁴⁰

236. UNITED STATES DEPARTMENT OF ENERGY OFFICE OF POLICY AND INTERNATIONAL AFFAIRS AND OAK RIDGE NATIONAL LABORATORY, BEHAVIORAL RESEARCH WORKSHOP: RESIDENTIAL BUILDINGS ENERGY EFFICIENCY DRAFT SUMMARY REPORT 8 (February 26, 2008).

237. KENTUCKY ENVTL. EDUC. COUNCIL, THE 2004 SURVEY OF KENTUCKIANS’ ENVTL. KNOWLEDGE, ATTITUDES AND BEHAVIORS (Frankfort, KY: KEEC, January 2005).

238. Sovacool & Sovacool, *supra* note 37.

239. *Id.*

240. *Id.*

CONCLUSION

The pervasive water challenges confronting the electric utility industry in the United States suggest that local regulators, public utility commissioners, water managers, and electric utility operators start immediately responding to them. The water needs for expected future thermoelectric power plants—if they continue to use twenty-five gallons of water per kWh as they do today—in just eight metropolitan areas are so immense they could deplete the water available from Lake Lanier in Georgia and exacerbate interstate litigation between Tennessee, Alabama, and Florida by 2025. Biodiversity could perish along the Catawba-Watauga River Basin in North Carolina. Chicago could find itself embroiled in domestic and international legal disputes over the consumption and withdrawal of water from Lake Michigan. Households and businesses could run out of water from the South Platte River in Colorado. Rivers could stop recharging the groundwater needed for drinking and irrigation in Texas. Lake Mead and the Colorado River could continue to suffer drought in Nevada, inducing an agricultural crisis in California and Mexico. Fisheries along the Hudson River in New York could collapse. The Delta Smelt could become extinct in the San Joaquin River Basin in California. These impending but avertable risks serve an important reminder that climate change is not the only serious environmental issue facing the electricity industry.

Thankfully, lawmakers and electric utilities can implement six changes that would do much to avoid water shortages in the future. They could increase funding for research and development on new and alternative power plant cooling cycles, and place a moratorium on all new thermoelectric capacity additions, preserving the water available for other industrial, residential, and agricultural needs. They could aggressively implement energy efficiency and demand-side management programs to displace the need to construct new power plants. They could seriously deploy wind and solar power systems that use virtually no water when they generate electricity. (The combination of investments in energy efficiency, wind, and solar would not need to replace existing thermoelectric power plants, just offset new thermoelectric capacity additions.) Regulators could improve the feedback and information given to their electricity consumers about the electricity-water nexus and the water intensity of their own consumption habits. They could also form an interstate organization or approach the federal government for assistance in designating National Electricity-Water Crisis Areas.

Interestingly, many of these actions would partially respond to a host of other challenges facing the industry unrelated to the use of water. The promotion of energy efficiency, wind, and solar would significantly reduce greenhouse gas emissions within the electricity sector, as all three technologies are less carbon intensive. A moratorium on future thermoelectric capacity additions would help diversify the fuels used to generate electricity, integrating more efficiency, solar, and wind into utility portfolios and serving as a hedge against fuel shortages and price volatility. Altering electricity prices would cut peak demand and create more informed consumers, an essential step towards any transition to a more decentralized electric utility sector involving small-scale distributed generation technologies. In this way, the proposals outlined here would not just save water and conserve electricity, but would also fight climate

change, improve energy security, and educate electricity users. The benefits of such action surely extend beyond merely water and the electricity industry to society as a whole.