Union of Concerned Scientists

Water Dependence Risks for America's Aging Coal Fleet

The U.S. power sector is facing a period of dramatic change. Coal is becoming a less viable option for power generation as natural gas prices decline, renewable energy sources become more cost competitive, and regulations to reduce emissions and public health impacts are implemented. In 2012, 37 percent of the nation's electricity was produced by coal-fired power plants, down from 48 percent in 2008 (EIA 2012). Climate change makes coal-based electricity risky as well. In the coming years, increasingly warm and dry conditions and longer droughts will contribute to changes in water availability in many parts of the country, posing problems for many power plants—including coal-fired plants—that require water to operate (primarily to cool the steam that powers electricity-generating turbines).

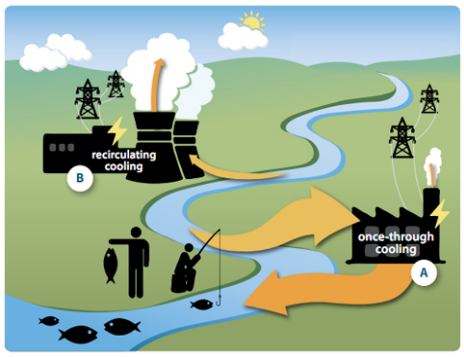
Coal plants are among the most water-intensive energy technologies, and thus will be vulnerable to energy-water "collisions" in which insufficient or too-hot cooling water limit plants' ability to provide reliable electricity at times when electricity demand is highest. The majority of these plants are also old, inefficient, and polluting; coal plants are a major source of air pollutants such as mercury, sulfur dioxide, and particulates, and are the nation's single-largest source of heat-trapping carbon dioxide emissions. Replacing these aging water-hungry plants with technologies that require little or no water could mean significant water savings across the country and a cleaner, more resilient energy future.

Hundreds of Coal Generators Are Ripe for Retirement

Three-quarters of the generators at U.S. coal plants[1] have exceeded their 30-year expected life span. A growing number of these generators have been judged a bad investment by their owners and scheduled for closure. To evaluate the economic competitiveness of the remaining U.S. coal fleet, the Union of Concerned Scientists (UCS) compared the cost of producing electricity from individual generators—after installing any needed pollution controls for sulfur dioxide, nitrogen oxides, mercury, and particulates (or soot)—with the cost of generating electricity from cleaner alternatives (Cleetus et al. 2012). If a coal-fired generator would be more expensive to operate than an efficient natural gas combined cycle (NGCC) plant or wind power facility, we considered the generator a candidate for closure—or "ripe for retirement."

Our analysis found that up to 353 coal generators, totaling 59 gigawatts (GW) of capacity, are ripe for retirement.[2] This excludes the 288 coal generators, totaling 41 GW of capacity, that had already been announced for retirement prior to our analysis. As of March 2013, power producers have announced the closure of another 70 coal generators totaling nearly 9 GW of capacity, including 58 identified in our report. As a result, there are 295 generators remaining on the ripe-for-retirement list, totaling 52 GW of capacity.

Figure 1. Power Plant Cooling Systems



The majority of ripe-for-retirement coal generators in the United States use once-through cooling systems (A), which withdraw enormous amounts of water but return it—at much higher temperatures—to the source. Recirculating systems (B) withdraw much less water, but evaporate (consume) much of it in the cooling process.

Coal Plants: Thirsty for Power

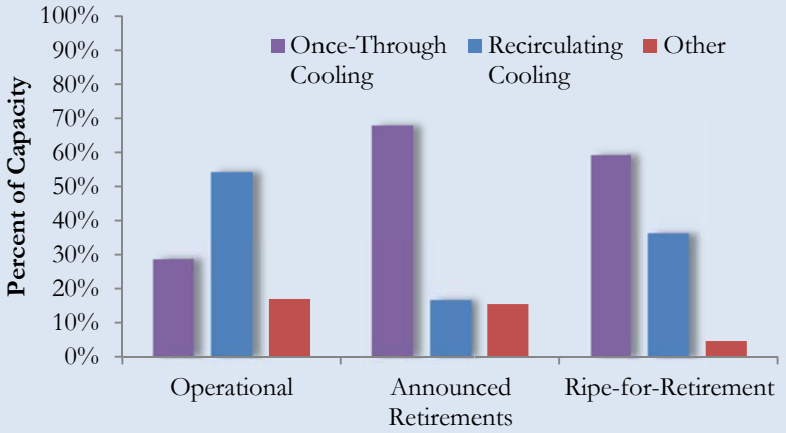
In addition to considering the cost of pollution controls when upgrading a coal generator, it is important to consider the environmental and economic costs associated with its water use. Water is critical to the operation of most coal, natural gas, and nuclear plants, as well as some renewable energy facilities, because it cools and condenses the steam that drives electricity-generating turbines. The operational risk this water dependence creates compounds the economic risks already faced by all coal generators. The magnitude of water withdrawals and consumption (evaporation)

[1] A power plant comprises one or more generating units, or generators.
[2] Numbers based on the "high estimate" in the analysis (Cleetus et al. 2012).

by water-cooled power plants depends on a variety of factors including climatic conditions, the location of the plant, and the time of year. However, the fuel type and cooling system are strong determinants of water use at any given power plant.

There are two major types of cooling systems used by power plants: **once-through** and **recirculating**. (See Figure 1 for an explanation of each.) Both systems utilize water from local sources such as rivers, lakes, or aquifers. A recent study by UCS-organized researchers found that, in 2008, water-cooled power plants in the United States withdrew an average of 60 to 170 billion gallons of freshwater per day and consumed 2.8 to 5.9 billion gallons of that water. Coal plants alone were responsible for 67 percent of those withdrawals and 65 percent of that consumption (Averyt et al. 2011); overall, coal plants account for more than one-quarter of all freshwater withdrawals in the United States (Kenny et al. 2009).

Figure 2. Once-Through Cooling Prevalent among Ripe-for-Retirement Coal Generators



Coal generators deemed ripe for retirement, as well as coal generators already announced for retirement, disproportionately employ once-through cooling technology that withdraws enormous amounts of water from lakes and rivers for one-time use, rather than withdrawing less and recirculating it. A small number of generators use other cooling technologies, such as cooling ponds.

Coal plants with once-through cooling are among the most water-intensive energy sources. Each of these plants withdraws between 20,000 and 50,000 gallons for each megawatt-hour (MWh) of electricity it produces, while an NGCC plant with once-through cooling withdraws only 7,500 to 20,000 gallons per MWh. Likewise, a coal plant with recirculating cooling consumes between 480 and 1,100 gallons per MWh, while a NGCC plant with recirculating cooling consumes only 130 to 300 gallons per MWh (Macknick et al. 2012).

Recirculating systems are not without their drawbacks. While they withdraw significantly less water, potentially reducing a power plant's vulnerability in a future of uncertain water availability, such systems *consume* more water than once-through systems, putting additional stress on freshwater sources that are already strained. In addition, by reusing water and requiring more energy to operate the cooling system, these plants are less efficient and potentially generate more heat-trapping emissions overall.

Energy-Water Collisions Are Already Happening

Across the country, water demand from power plants is combining with pressure from growing populations and other needs and straining water resources—especially during droughts and heat waves. Several ripe-for-retirement plants with once-through cooling have already experienced these energy-water collisions.

During a 2007 heat wave, for example, the G.G. Allen coal plant in North Carolina was forced to cut power generation as the temperature of its discharged cooling water exceeded limits set to protect fish in the Catawba River (Beshears 2007). The plant has since been granted a special exception to its water discharge permit that allows it to exceed state temperature limits (EPA 2013a). Similarly, the Joliet Station in Illinois was given permission to release water above temperature limits by the Illinois Environmental Protection Agency during the summer of 2012 in the face of extremely warm weather conditions (IGNN 2012). Without these exceptions, these plants would not be able to operate when temperatures are highest—often coinciding with periods of peak power demand.

Other plants have had to implement backup measures to continue operating. In Georgia, the Hammond coal plant had to rely on portable cooling towers during the summers of 2007 and 2008 in order to meet water discharge temperature limits set for the Coosa River by the Environmental Protection Agency (EPA) (EPRI 2008).

Brayton Point: Are Costly Retrofits Worth It?

Since 2007, Dominion Energy has invested more than $1 billion upgrading its Brayton Point coal-fired power plant in Somerset, MA, including new scrubbers to control sulfur dioxide emissions and a $570 million recirculating cooling technology retrofit (DOM 2013). According to a recent study by Conservation Law Foundation, however, the plant is facing an uncertain economic future because it is unable to compete with power plants fueled by less-expensive natural gas (Schlissel and Sanzillo 2013). Use of the plant's three generators fell from 72 percent of maximum generating capacity in 2009 to 21 percent in 2012. Brayton Point's economic hurdles serve as a cautionary tale for other coal plants considering costly upgrades.

Table 1. Top 10 Power Companies with Most Ripe-for-Retirement Generators Using Once-Through Cooling

Rank	Utility Company	Capacity (GW)	# of Units
1	Southern Company	5.8	26
2	Tennessee Valley Authority	3.6	17
3	GenOn Energy Inc. (NRG Energy)	2.2	11
4	FirstEnergy Corp.	2.1	7
5	Public Service Enterprise Group Inc.	1.7	4
6	Wisconsin Energy Corp.	1.6	9
7	Duke Energy Corp. (Progress Energy, Inc.)	1.6	9
8	DTE Energy Company	1.2	7
9	SCANA Corp.	1.0	2
10	Dominion Resources, Inc.	0.9	5

The increasing environmental and operational risks of once-through plants like these will be compounded by regulations that protect rivers, lakes, and streams (Georgakakos et al. 2013). Current EPA regulations, such as the National Pollutant Discharge Elimination System, set limits on the temperature of water discharged from power plants (EPA 2007). Additional EPA rules under section 316(b) of the Clean Water Act, which require power plants to employ cooling water intake structures that minimize negative environmental impacts, are expected to be finalized by June 2013 (EPA 2013b). Because these regulations primarily affect plants with once-through cooling systems, owners of these plants may have to either upgrade to costly recirculating cooling systems or retire them and invest in cleaner, lower-cost options.

Such decisions are particularly relevant for plants that are already at risk economically. UCS found that 175 of the 295 remaining ripe-for-retirement generators have once-through cooling systems. (This is not surprising given that once-through cooling is an older technology; the average age of once-through coal plants, weighted by their electricity generating capacity, is 47 years compared with only 24 years for recirculating plants.) These 175 units collectively account for about 31 GW of generation capacity, or 59 percent of total ripe-for-retirement capacity (see Figure 2). Southern Company, one of the nation's largest electricity producers, owns more of these generators than any other utility company (see Table 1). Its 26 generators, located in Alabama, Florida, Georgia, and Mississippi, total nearly 5.8 GW of coal capacity. Three other utilities—Tennessee Valley Authority, GenOn, and FirstEnergy—each have more than 2 GW of ripe-for-retirement capacity from generators that use once-through cooling.

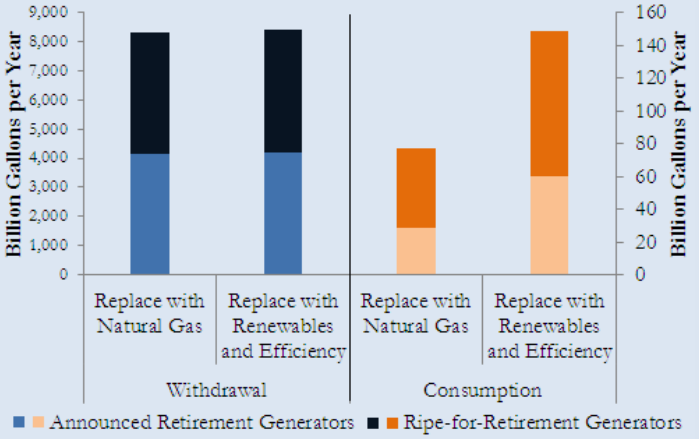
These generators are economically uncompetitive even *before* considering the cost of upgrading to recirculating cooling systems. Therefore, the potential cost of reducing water dependency makes them even stronger candidates for closure. Of the once-through coal generators that are not on the ripe-for-retirement list (i.e., that passed our initial economic test for pollution controls), 29 percent (66.8 GW) may be less competitive compared with cleaner, more affordable energy sources when adding the expected costs of recirculating cooling systems (see the Brayton Point box, above).

Retiring Old Coal Generators Yields Big Water Savings

In a warmer, water-constrained world, our energy choices matter greatly. Significant water savings will result from coal generators that are already announced for retirement. Replacing ripe-for-retirement generators with less water-intensive generating sources will reduce water use even further.

For example, if all coal generators already announced for retirement (368 units, 51 GW) were replaced with NGCC generators with recirculating cooling systems, annual water withdrawals would drop by 4,166 billion gallons and water consumption by 29 billion gallons.[3] If all 295 ripe-for-retirement generators, totaling 52 GW of capacity, were also replaced with such NGCC plants, annual water withdrawals would drop an additional by 4,164 billion gallons and water consumption by an additional 49 billion gallons. However,

Figure 3. Water Savings Potential from Coal Retirements



As coal generation is replaced with natural gas or renewables and energy efficiency, water withdrawal and consumption savings are realized. Savings are calculated based on the estimated median amount of water withdrawn and consumed for given fuel and cooling types.

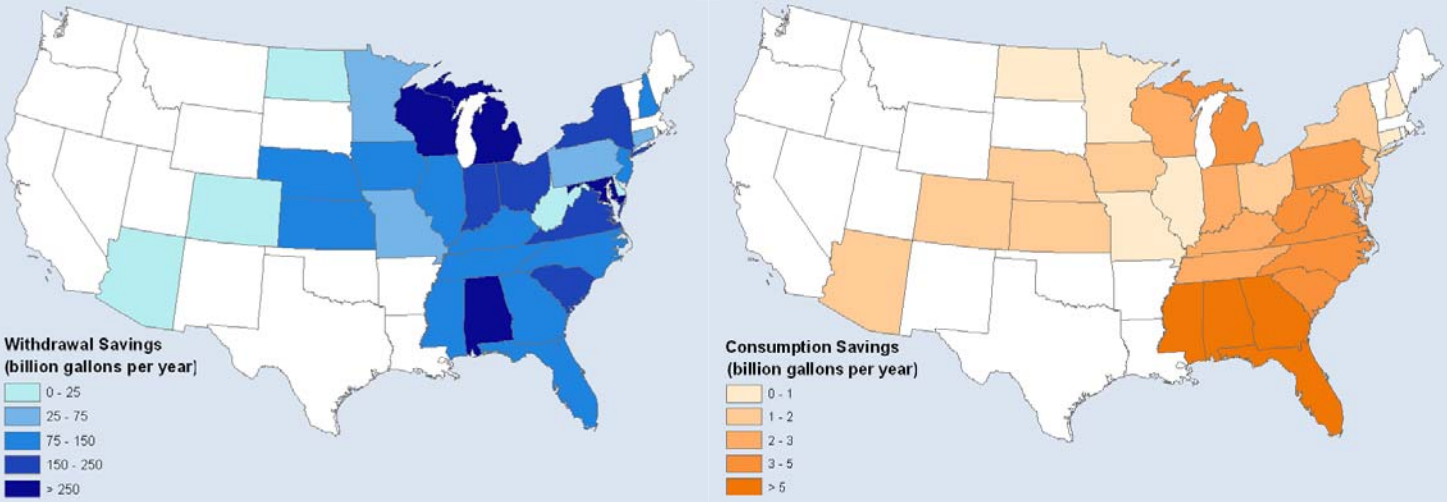
[3] Actual water use depends on a variety of factors, and estimated water withdrawal and consumption falls within a range (Macknick et al. 2012). Water savings are calculated based on the estimated median water use of each coal unit.

this does not include water use in natural gas extraction by hydraulic fracturing, which can be locally significant.

Water demand would be reduced even more dramatically if coal-fired generation were replaced with renewable energy technologies that use essentially no water—like wind and solar photovoltaic—or with energy-efficient technologies that reduce electricity demand overall. Approximately 8,421 billion gallons of water withdrawals and 149 billion gallons of water consumption could be avoided if both retiring and ripe-for-retirement generators were replaced with renewables and efficiency (see Figure 3).

The water impacts of ripe-for-retirement generators vary across the country, but are concentrated in a few key states where the greatest number of once-through coal generators are located and where power plants operators are already facing energy-water collisions (see Figure 4). States like Alabama, Maryland, Michigan, and Wisconsin could each save more than 250 billion gallons of water withdrawals a year by replacing uncompetitive coal generators with renewable energy. Similarly, Alabama, Florida, Georgia, and Mississippi could each save more than 5 billion gallons annually in water consumption.

Figure 4. Water Withdrawal and Consumption Savings by State



Water withdrawal and consumption savings are based on median water use for each coal unit. Savings shown are from retiring coal units on the updated ripe for retirement list and replacing them with renewable energy sources or reduced demand due to energy efficiency.

A More Resilient Energy Future

A large share of the nation's coal fleet is economically uncompetitive with cleaner energy sources when accounting for the costs of upgrading to modern air pollution control equipment that would reduce public health impacts. Water dependency creates additional operational risks for many of these coal generators, given the growing need to address energy-water collisions that threaten the reliability of coal generation and the adequacy of water resources. Coal-fired power plants are also one of the biggest contributors to U.S. global warming emissions. All of these arguments suggest that investing in aging coal plants is unsound.

Instead, utilities and investors should channel energy investments towards energy sources that do not emit harmful pollutants and do not put undue pressure on limited freshwater resources. And, before approving costly retrofits, utility regulators should require utility companies to conduct system-wide planning to determine whether cleaner energy resources can more affordably meet customers' energy needs. Policies that encourage increased investments in renewable energy and energy efficiency can help reduce the health and environmental impacts of our nation's power supply, and help shift the United States toward a cleaner, safer, and more reliable energy future.

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