US, European nuclear and coal-fired electrical plants vulnerable to climate change: study

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Warmer water and reduced river flows in the United States and Europe in recent years have led to reduced production, or temporary shutdown, of several thermoelectric power plants. For instance, the Browns Ferry Nuclear Plant in Alabama had to shut down more than once last summer because the Tennessee River's water was too warm to use it for cooling.

A study by European and University of Washington scientists published today in *Nature Climate Change* projects that in the next 50 years warmer water and lower flows will lead to more such power disruptions. The authors predict that thermoelectric power generating capacity from 2031 to 2060 will decrease by between 4 and 16 percent in the U.S. and 6 to 19 percent in Europe due to lack of cooling water. The likelihood of extreme drops in power generation—complete or almost-total shutdowns—is projected to almost triple.

"This study suggests that our reliance on thermal cooling is something that we're going to have to revisit," said co-author Dennis Lettenmaier, a UW professor of civil and environmental engineering.

Thermoelectric plants, which use nuclear or fossil fuels to heat water into steam that turns a turbine, supply more than 90 percent of U.S. electricity and account for 40 percent of the nation's freshwater usage. In Europe, these plants supply three-quarters of the electricity and account for about half of the freshwater use.

While much of this water is "recycled," the power plants rely on consistent volumes of water, at a particular temperature, to prevent the turbines from overheating.

Reduced water availability and warmer water, caused by increasing air temperatures associated with climate change, mean higher electricity costs and less reliability.

While plants with cooling towers will be affected, results show older plants that rely on "once-through cooling" are the most vulnerable. These plants pump water directly from rivers or lakes to cool the turbines before returning the water to its source, and require high flow volumes.

The study projects the most significant U.S. effects at power plants situated inland on major rivers in the Southeast that use once-through cooling, such as the Browns Ferry plant in Alabama and the New Madrid coal-fired plant in southeastern Missouri.

"The worst-case scenarios in the Southeast come from heat waves where you need the power for air conditioning," Lettenmaier said. "If you have really high power demand and the river temperature's too high so you need to shut your power plant down, you have a problem."

The study used hydrological and water temperature models developed by Lettenmaier and co-author John Yearsley, a UW affiliate professor of civil and environmental engineering. The European authors combined these with an electricity production model and considered two climate-change scenarios: one with modest technological change and one that assumed a rapid transition to renewable energy. The range of projected impacts to power systems covers both scenarios.

The U.S. and Europe both have strict environmental standards for the volume of water withdrawn by plants and the temperature of the water discharged. Warm periods coupled with low river flows could thus lead to more conflicts between environmental objectives and energy production.

Discharging water at elevated temperatures causes yet another problem: downstream thermal pollution.

"Higher electricity prices and disruption to supply are significant concerns for the energy sector and consumers, but another growing concern is the environmental impact of increasing water temperatures on river ecosystems, affecting, for example, life cycles of aquatic organisms," said first author Michelle van Vliet, a doctoral student at the Wageningen University and Research Centre in the Netherlands.

Given the high costs and the long lifetime of power plants, the authors say, such long-range projections are important to let the electricity sector adapt to changes in the availability of cooling water and plan infrastructure investments accordingly.

One adaptation strategy would be to reduce reliance on freshwater sources and place the plants near saltwater, according to corresponding author Pavel Kabat, director of the International Institute for Applied Systems Analysis in Austria and van Vliet's doctoral adviser.

"However, given the life expectancy of power plants and the inability to relocate them to an alternative water source, this is not an immediate solution, but should be factored into infrastructure planning," he said. "Another option is to switch to new gas-fired power plants that are both more efficient than nuclear- or fossil-fuel-power plants and that also use less water."

More information: Vulnerability of US and European electricity supply to climate change. Michelle T. H. van Vliet, John R. Yearsley, PHYS.ORG

Fulco Ludwig, Stefan Vögele, Dennis P. Lettenmaier and Pavel Kabat. Nature Climate Change, 10.1038/NCLIMATE1546 , June 3 2012.

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