University of New Hampshire

Media Relations

April 22, 2013

Rivers Act as “Horizontal Cooling Towers,” Study Finds

Caption: Coal-fired power plant on the Merrimack River in Bow, N.H. The plant discharges warmed water to the river which then transports, dilutes, and re-equilibrates heat. Courtesy of ASSIST Aviation Solutions.

DURHAM, N.H. -– Running two computer models in tandem, scientists from the University of New Hampshire have detailed for the first time how thermoelectric power plants interact with climate, hydrology, and aquatic ecosystems throughout the northeastern U.S. and show how rivers serve as “horizontal cooling towers” that provide an important ecosystem service to the regional electricity sector — but at a cost to the environment.

The analysis, done in collaboration with colleagues from the City College of New York (CCNY) and published online in the current journal Environmental Research Letters, highlights the interactions among electricity production, cooling technologies, hydrologic conditions, aquatic impacts and ecosystem services, and can be used to assess the full costs and tradeoffs of electricity production at regional scales and under changing climate conditions.

Lead authors of the study are Robert Stewart of the UNH Institute for the Study of Earth, Oceans, and Space (EOS) and Wilfred Wollheim of the department of natural resources and environment and EOS.

Thermoelectric power plants boil water to create steam that in turn drives turbines to produce electricity. They provide 90 percent of the electricity consumed nationwide and an even a greater percentage in the Northeast — a region with a high density of power plants.

Cooling the waste heat generated during the process requires that prodigious volumes of water be withdrawn and makes the thermoelectric sector the largest user of freshwater in the U.S. — withdrawing more than the entire, combined agricultural sector. Water withdrawals are either evaporated in cooling towers or returned to the river at elevated temperatures. Rivers can help mitigate these added heat loads through the ecosystem services of conveyance, dilution, and attenuation — essentially acting as horizontal cooling towers as water flows downstream.

Says Stewart, a research scientist in the EOS Earth Systems Research Center, “Our modeling shows that, of the waste heat produced during the production of electricity, roughly half is directed to vertical, evaporative cooling towers while the other half is transferred to rivers."

The study also shows that, of the waste heat transferred to rivers, only slightly more than 11 percent wafts into the atmosphere with the rest delivered to coastal waters and the ocean.

"We were surprised to find that relatively little of the heat to rivers is exchanged back to the atmosphere," notes Wollheim, an assistant professor and co-director of the Water Systems Analysis Group at EOS. Wollheim adds, "Reliance on riverine ecosystem services to dispense waste heat alters temperature regimes, which impacts fish habitat and other aquatic ecosystem services."

The researchers quantified the various dynamics using a spatially distributed hydrology and water temperature model developed at UNH known as the Framework for Aquatic Modeling in the Earth System, or FrAMES model, coupled with the Thermoelectric Power and Thermal Pollution Model developed by collaborators at CCNY.

The combined models showed that there are roughly 4,700 river miles in the region potentially impacted by power plants. The study found that, in general, the impact to river temperatures, and thus fish habitat, is "considerable" and disruptions in river flow "minimal," in part because so many of the region's power plants are located well down river near coastal areas.

But the study also noted that in the face of changing climate and increasing energy demand, "it is essential to assess the capacity and associated environmental trade-offs of heat regulating ecosystem services that support the electricity sector."

Indeed, last summer a reactor at the Millstone nuclear power plant in Waterford, Conn. was shut down because the water in Long Island Sound was too warm to cool it—something utterly unanticipated when the plant was designed in the 1960s. And in July 2012, a nuclear plant in Illinois had to obtain special permission to continue operations because its cooling water pond reached 102 degrees in the wake of low rainfall and high air temperatures.

By means of the study, notes Wollheim, "We can better understand the unintended consequences to other ecosystem services as we rely on rivers to support generation of electricity. Integrative, regional approaches will be needed to help plan as society adapts to changing climate and hydrology while demand for power continues to increase."

The work was funded by the National Science Foundation through the Earth System Modeling Program and NSF's *Experimental Program to Stimulate Competitive Research (*EPSCoR) program, and by the U.S. Environmental Protection Agency.

Project collaborators and co-authors on the Environmental Research Letters paper include UNH's Richard Lammers, and Ariel Miara, Charles Vörösmarty, Balazs Fekete, and Bernice Rosenzweig of CCNY.

To read the paper, visit http://iopscience.iop.org/1748-9326/8/2/025010

Watch an interview with UNH researchers Robert Stewart and Wilfred Wollheim about this research: http://bcove.me/8b5ohckf

Photograph to download: http://www.eos.unh.edu/newsimage/coolingtowers_lg.jpg
Caption: Coal-fired power plant on the Merrimack River in Bow, N.H. The plant discharges warmed water to the river which then transports, dilutes, and re-equilibrates heat. Courtesy of ASSIST Aviation Solutions.

The University of New Hampshire, founded in 1866, is a world-class public research university with the feel of a New England liberal arts college. A land, sea, and space-grant university, UNH is the state's flagship public institution, enrolling 12,200 undergraduate and 2,300 graduate students.

-30-

Media Contact: David Sims | 603-862-5369 | Institute for the Study of Earth, Oceans, and Space

---