Researcher sees laptop-cooling technology as way to less-thirsty power plants

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Every minute in the United States, power plants that generate electricity use nearly triple the amount of water that surges over Niagara Falls during that same time, according to the Union of Concerned Scientists.

In an era of drought and diminishing aquifers, freshwater sources are an ever-more-precious resource—and power plants' use of freshwater has become a critical issue. One researcher at the University of Kansas is investigating new ways to cool plants more efficiently with technology used in everyday laptop computers.

"Every time you recharge a smartphone or watch TV, you're consuming water as well as fuel," said Theodore Bergman, the Charles E. & Mary Jane Spahr Professor and chair of the Department of Mechanical Engineering at KU. "Electric power generation, specifically cooling of power plants, accounts for approximately 40 percent of the nation's total freshwater withdrawals, far surpassing any other sector including agriculture, which is a distant second."

Bergman said the traditional method for cooling power plants is once-through cooling from a river or lake, where warm water is returned to the source, which could alter ecosystems and have other undesirable effects.

"The most common method for water cooling is to evaporate the liquid coolant, resulting in the huge clouds of water vapor that can be seen rising from electric power generating stations," he said. "We're seeking approaches to eliminate or drastically reduce water evaporation."

With a new grant from the National Science Foundation, Bergman is looking at how power plants instead might be cooled with the same kind of "closed thermosyphons" that are commonly used to keep laptop computers from overheating.

"To my knowledge, every laptop computer has a cooling system that includes a closed thermosyphon, or heat pipe," Bergman said. "To date, closed thermosyphons have not been used at the scale necessary to impact electric power generation."

Thermosyphons use passive heat exchange without the need for pumps. Instead they rely on convection to move a liquid coolant, which vaporizes when hot and then condenses as it cools, becoming ready for re-use.

Bergman said employing large-scale thermosyphons within power plants could save water and cut construction and operation costs.

"Instead of evaporating liquid water that escapes to the environment, a two-phase closed thermosyphon evaporates a working fluid—it can be water—that is condensed at the far end of the device," he said. "No vapor escapes to the environment. Thermosyphons operate passively, have no moving parts, and are inexpensive and lightweight." Bergman said that fundamental laws of physics require a resistance to the flow of heat expelled from an electric power generating station "just as there is a resistance to the flow of electrons."

He said a key challenge is to build large thermosyphons that have very small thermal resistance. His research will consider the use of fins or metal foams.

"We're investigating the advantages of fins, metal foams and other approaches used in conjunction with thermosyphons," Bergman said. "Heat flows from the power plant to the thermosyphons and fins—or foams—and ultimately to air. Forcing air through the fins or foams requires a fan, and the power consumed by the fans, each of which might require as much electricity as needed for 100 homes, is proportional to the drop in pressure of the air as it flows through the media."

According to Bergman, these physical mechanisms are complex and highly coupled, and understanding how they interact is the most difficult challenge of the project. His team will develop and solve the fundamental equations that describe the underlying physics through computer coding.

However, Bergman said newly engineered designs for plant cooling soon could make their way into power plants that provide electricity to consumers in the real world.

"I anticipate new cooling technologies, such as the one we are developing, to be commercialized within the next decade," he said.

Provided by University of Kansas