New nanoparticle technology cuts water use, energy costs

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In order to cut down on the enormous quantities of water required to operate steam generators at large power stations in the United States, scientists have begun to look for new technologies that could improve their efficiency and reduce the demand for water.

Nuclear and coal power plants are some of the thirstiest machines on earth. The turbines that spin inside of them to generate electricity require tons and tons of steam, and all of that water has to come from somewhere.

Recent studies have estimated that roughly two-fifths of the nation's freshwater withdrawals and three percent of overall freshwater consumption goes to supplying the steam generators at large power stations in the United States. In order to cut down on the enormous quantities of water required to operate these plants, scientists have begun to look for new technologies that could improve their efficiency and reduce the demand for water.

As part of a larger consortium involving partners from several energy companies, universities, and government agencies, researchers at the U.S. Department of Energy's Argonne National Laboratory are developing a special class of nanoparticles that partially melt as steam evaporates from a plant's cooling towers, absorbing a significant percentage of the diffused heat in the system.

In order to operate, electrical plants use a cycle that uses partially condensed high-temperature steam to turn a large turbine. During generation, a significant quantity of this steam is lost due to evaporation. "In every cycle, there's a significant amount of water that we can't recapture," said Argonne materials scientist Dileep Singh, who is working to develop the specialized nanoparticles.

The nanoparticles are based on what is known as a "core-shell" configuration, in which a solid outer coat protects an inner layer that can melt above a certain temperature. Once dispersed in the plant's water supply, the nanoparticles are able to absorb heat during the thermal cycle. After partially melting, the particles travel to the cooling tower where they resolidify. The system is closed and designed to ensure against leakage of the plant's water or steam into the environment.

At the molecular level, Singh and his colleagues are especially concerned with the surface of the nanoparticles, as the chemistry at the boundary between the metal and the water determines how much heat the particles can take up. "We're experimenting with looking at the bonding between the particles and the water molecules," he said.

"What we really want to know is how much heat we can pick up given a constant amount of water to cool the system," he added. "Environmentally responsible energy growth involves worrying about how you manage your water resources."

The vast quantities of water that are needed to operate these facilities will necessitate the mass production of the nanoparticles once they are commercially developed, a fact that could potentially complicate the research and development process, said Argonne associate division director Thomas Ewing. "As we begin lab testing, we need to keep in mind the costs and issues associated with making this work in a real live power plant," he said. "There are lots of tradeoffs to take into account."

According to Ewing, Argonne is working with the Electric Power Research Institute and other partners to move this basic technology quickly through the developmental pipeline. Initial plans call for the demonstration of proof of concept to commence this year and full-scale commercial deployment to begin in four years. "It's practically unheard of for industry to seek to deploy a new technology so quickly," Ewing said. "However, water consumption is a major issue that limits the expansion of power. If we want to solve the energy crisis, we'll have to move boldly."

Provided by Argonne National Laboratory