# Remote technology sees through ice, snow and hot air to monitor power plants

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On Aug. 14, 2003, the power grid failure that left the northeastern United States in darkness surprised a country unaccustomed to interrupted electricity. Expectations of a plentiful energy supply in the United States contrast dramatically to the situation in some developing countries that limit public use of electricity to a few hours a day. Monitoring the amount of power produced by some of these countries is a U.S. national concern.

The U.S. Department of Energy is funding the development of technology that will aid in the remote observation of power plants to gauge the actual amount of energy produced. The DOE has awarded Rochester Institute of Technology a total of $1.4 million on two related projects to perfect the detection of observable "signatures" at power plants. The studies will focus on power plants that cool their condensers by extracting water from cooling lakes that have frozen and another more conventional method using fans in locations where a body of water is not readily accessible. Carl Salvaggio, associate professor in RIT's Chester F. Carlson Center for Imaging Science, and two of his graduate students are solving these complex puzzles for the DOE's Savannah River National Laboratory.

Seeing through Ice and Snow: This winter, Salvaggio, graduate student May Arsenovic, and a team of research faculty and staff members will study the frozen cooling lake at a traditional gas-powered plant in Midland, Mich. It's the only cooling lake in the United States large enough to freeze because it was originally created for a nuclear facility never built.

Infrared sensors flown overhead can detect and "read" hot water plumes discharged into cooling lakes. Salvaggio's colleagues at the Savannah River National Laboratory already can predict a power plant's energy production by the turbulent underwater mixings of hot and cold water. But cover the lake with ice and the physical properties behind the thermal distribution—key to modeling and predicting power levels—are blocked from view. A small melt hole is the only observable clue for scientists to study.

"The research on this project is about how ice acts as an insulator and to determine how much energy is kept inside the lake because there's an ice layer over it," Salvaggio says. "The size of the melted hole is our only observable, so we have to be able to figure out from that what the power levels are."

Once a week, starting in November and running through April, a small plane will fly overhead in Midland taking images of the frozen lake. The scientists will use thermal infrared imagery to determine the temperature of the discharged hot water and passive microwave remote sensing—which has a longer wavelength than infrared—to determine the thickness of the insulating snow and ice layer and to estimate its insulating capacity.

Salvaggio, Arsenovic and Alex Long, a high-school intern from Bloomfield, N.Y., will use three different technologies to measure ice thickness on the ground to determine how accurately their airborne techniques are working. They will explore ultrasound; temperature profiles of ice, water and air at fine spatial increments; and, using a blue LED/photodiode combination, measure the loss in brightness from the LED through the ice, water and air at many different points throughout these layers.

## Measuring Hot Air

Cooling towers take the place of lakes at power-generating facilities built in locations without easy access to bodies of water. These towers function as radiators to cool off condensers, using fans to create a mechanical draft pushing the warm air upward. Salvaggio and his team are trying to measure the temperature of the hot air released from the tower.

"This is a trickier problem because we're trying to see hot air, and you can't see hot air," Salvaggio notes.

Salvaggio and his team will infer power production based on surface temperatures of fan blades, support structures and motors. The water temperature going in and coming out of the tower will show how much heat was picked up from the power plant or off the condenser. Graduate student Matt Montanaro is working with images provided by Savannah River National Laboratory of towers at its site in South Carolina.

"We're doing mathematical modeling to try to understand how a photon—a unit of light—bounces around inside a complex target like a cooling tower and eventually comes out," Salvaggio says. "And when we detect that, we can actually get an accurate temperature of the surfaces inside."

The imaging problems posed by the frozen cooling lake and the cooling tower studies can be understood by mathematical modeling and through scientific simulations using a computer program initially developed at RIT in 1984.

This simulated world is akin to many popular social networking sites. It is driven by computer graphics codes that accurately predict brightness (important for comparing data from different wavelengths), and is completely governed by the rules of physics. The computer program, known as Digital Imaging and Remote Sensing Image Generation model (http://dirsig.cis.rit.edu/), provides a platform for testing scenarios based on imaging problems.

Source: Rochester Institute of Technology