In the Field

Miniature Monitoring

EPRI Investigates the Potential of Environmental Microsensors in Utility Applications

By Brent Barker

Advances in electronics manufacturing are driving the proliferation of small, portable, inexpensive environmental sensors. These microsensors are far less expensive than the larger monitoring equipment used today by the electric power industry for compliance with environmental regulations. However, the number of parameters that they can measure is limited, and the measurement quality is not regulatory-grade. Nevertheless, as their performance improves and costs come down, the future role of environmental microsensors is likely to expand.

"Monitoring equipment is being miniaturized," said EPRI Principal Technical Leader Stephanie Shaw. "Although microsensors don't include the complex analyzers and extra calibrations needed for regulatory compliance, they have the potential to provide utilities with screening data in unmonitored areas and supplement existing monitoring programs. They can run on batteries or small solar panels and are light enough to be carried by technicians, whereas regulatory-grade instruments are very bulky and often must be stored in climate-controlled cabinets."

To date, the quality of microsensor measurements has not been consistently high, though the U.S. Environmental Protection Agency (EPA), the California South Coast Air Quality Management District, and other industry stakeholders are working to improve measurement quality through thorough testing and comparison against reference instruments.

Microsensors may also put environmental monitoring in the hands of the public. Today it's feasible as part of emerging "citizen science" for the public to use smartphone-powered sensors to measure air quality near industrial facilities. This has spurred some utilities to work with EPRI to test these devices.

EPRI's SENTINEL project is investigating the potential of new microsensors, and electric utilities in the United States have hosted field studies of three applications: measuring airborne particulate matter near a coal-fired plant, measuring indicators of groundwater quality near a coal ash impoundment, and real-time monitoring of ground movement at a coal ash impoundment.

"We're trying to answer two questions," said EPRI Senior Technical Leader Bruce Hensel. "First, since there has been insufficient verification of the quality of these sensors, we want to find out what they can and cannot measure in the field and assess the accuracy of the data they capture. Second, if they work well, do they represent an opportunity for utilities to expand their environmental monitoring networks and save on monitoring costs?"

A microsensor for groundwater monitoring.

Environmental applications for microsensors potentially relevant to utilities include:

- Provide environmental data to help identify the best locations for regulatory-grade monitoring instruments
- Detect pollutants at power generation facilities
- Create early warning/detection systems
- Monitor worker exposure
- Educate local communities and other stakeholders about environmental conditions and other issues

Particulate Matter at Coal Piles

The utility hosting the study of particulate matter measurements wanted to know if microsensors could detect a dust plume coming from the power plant's on-site coal stockpiles. Those in long-term storage, typically a year or more, are coated with a sealant, while those being moved and conveyed into the plant are subject to wind and other weather.

Downwind of the coal piles, EPRI and the utility tested microsensors that measure various sizes of airborne particulate matter (1, 2.5, and 10 microns). Their accuracy was gauged relative to measurements from equipment whose precision is accepted by the U.S. federal government.

The nine-month test yielded mixed results for the microsensors. Comparisons to the reference monitor showed numerous false positives when the temperature fell below 0°C. The sensors didn't perform well in winter cold or summer humidity but did pick up the dust plume under more moderate conditions.

"The sensors are not perfect, but they are useful for screening. They can fairly reliably detect the presence of windblown dust and, when placed in multiple locations, give utilities a tool to inform action," said Shaw.

Measuring Ground Movement

Another utility's network of ground movement microsensors monitors the stability of berms (man-made embankments) at a coal ash impoundment. The utility has shared its real-time data with the SENTINEL team, which in turn will share with other industry stakeholders.

Sensors known as piezometers measure pore water pressure. In-place inclinometers measure the lateral displacement of a berm. Settlement plates characterize the interface between native soil and fill material, and other sensors measure soil settlement at various depths.

"The ground movement tests revealed that these are very sensitive instruments and provide a powerful data set capable of showing early stages of ground movement. This provides an early warning system for potential failure of berms, dikes, or impoundments at coal ash facilities, giving utilities time to take action to shore-up these structures before a catastrophic failure occurs," said Hensel.

Measuring Groundwater Quality

EPRI is also testing microsensors in a groundwater monitoring project at a coal ash management facility. At present, there is no suite of microsensors that can replace a comprehensive groundwater monitoring program, which relies on laboratory measurement of pH, total dissolved solids, sulfate, chloride, calcium, and boron as well as various trace elements, such as molybdenum and arsenic. Microsensors are available only for measuring pH, chloride, and electrical conductance (which provides a close parallel to total dissolved solids).

"Whereas the ground movement sensors are reliable and provide very useful information, sensors for groundwater monitoring are not as advanced," said Hensel. "For the most part, the groundwater sensors we need are not available. The ones that are available are not cost-effective yet; they are not always reliable and require routine maintenance."

That said, new microsensors can supplement traditional groundwater monitoring in a few applications. "Strategically positioned sensors can provide additional data between manual sampling events, particularly in karst and other groundwater systems with rapid flow," said Hensel.

"Wide Open" Future

"We wanted to give these new microsensors a solid test in practical applications at utility facilities, comparing them with the more expensive, sophisticated monitoring systems used by utilities today," said Shaw. "They are at an early stage of development, and we see promise if not perfection. Because of their portability and lower cost relative to other monitoring equipment, they are ready for some specific applications now—detecting a coal dust plume, characterizing water flow underground, providing early warning of dike instability. The future possibilities are wide open. EPRI will continue to track microsensor technologies with potential to provide more detailed environmental data and lower utilities' monitoring costs."

Key EPRI Technical Experts

Stephanie Shaw, Bruce Hensel