Robotic Transmission Line Inspection

Overhead transmission lines are among the utility industry's most widely distributed assets, traversing tens of thousands of miles, often in remote locations. Reliability requirements, component aging, and right-of-way inspection compliance drive the need for thorough, timely inspections along the entire length of these lines. Such comprehensive assessments by maintenance personnel, working on the ground or in aircraft, currently entail significant expense.

To expand inspection capabilities and increase cost-effectiveness, EPRI is developing a transmission line inspection robot designed to traverse 80 miles of line at least twice a year, collecting high-fidelity information that utilities can act on in real time. As the robot crawls the transmission line, it identifies high-risk vegetation and right-of-way encroachment and assesses component conditions by means of various inspection technologies. The robot will be essentially self-sufficient, using its solar panels to recharge its batteries and power its motion, communications, and data gathering and processing.

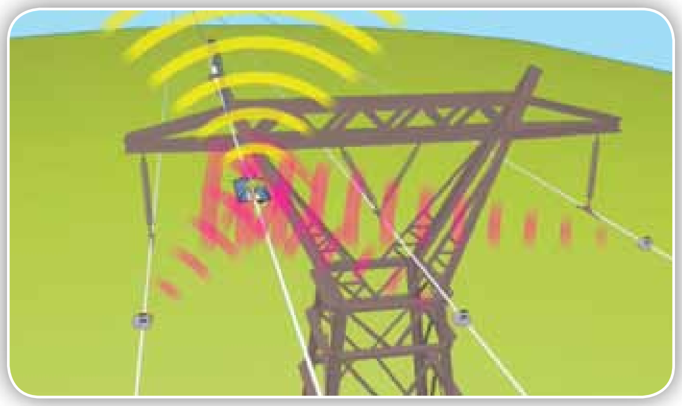
A Wealth of Inspection Equipment

One of the robot's main features will be a high-definition camera with advanced image processing to inspect the right-of-way and component conditions. Using images taken at two locations and factoring in precise parallax measurements, the robot will be able to determine clearances between conductors, trees, and other objects in the right-of-way. The camera also will be able to compare current and past images of specific components to identify high-risk conditions or degradation. As an alternative to the camera, the robot may be equipped with a Light Detection and Ranging (LiDAR) sensor to measure conductor position, vegetation, and nearby structures.

EPRI envisions that the robot will move at a pace that allows for detailed assessment. The objective will be to provide inspections that meet or exceed the quality of comprehensive examinations from a helicopter and that cover areas that are hazardous or difficult to access from the ground. The concepts and hardware that enable the robot to traverse transmission line structures are currently being patented, and the detailed design, implementation, and testing of these technologies are under way.

Connecting With Sensors

The robot will transmit key information to utility personnel, with a global positioning system accurately identifying its location and speed. Another system will collect data from remote sensors deployed along the line, and an electromagnetic interference detector will identify discharge activity, corona, or arcing. Where discharge is identified, field personnel may do further inspections using daytime discharge cameras.



The transmission line inspection robot will be able to gather information from line sensors of various types and relay information to maintenance personnel.

The conductor-crawling robot has been designed to work with a variety of EPRI-developed radio-frequency sensors that can be placed along transmission lines to provide real-time assessment of components such as insulators, conductors, and compression connectors. These sensors will likely be targeted for areas of environmental stress or where specific component types have been installed. For example, lightning sensors will be installed in high-lightning areas, vibration sensors will be used in high-wind areas, and leakage-current sensors will be deployed in coastal areas to detect salt contamination.

The deployed sensors will collect data continuously, develop histograms, and determine maximum values. Cached and current data will be transmitted to the robot when it is in close proximity and will then be transmitted to maintenance personnel. The inspection robots, when coupled with these sensors, will be able to provide comprehensive, accurate, and useful information to optimize line maintenance and improve transmission reliability. In some cases, the purchase of robots for use in place of maintenance crews could shift O&M expenses to capital costs, allowing a return on investment and depreciation.

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New Technology Produces Activated Carbon On Site

Activated carbon injection is one of the most promising options for the control of mercury emissions from coal-fired power plants. Its promise is constrained by its expense. At $0.75–$2/lb, commercially available activated carbon could cost a plant millions of dollars a year.

To provide the industry with a lower-cost alternative, EPRI and the Illinois State Geological Survey developed and patented a technology for the on-site production of activated carbon. The sorbent activation process uses coal from the plant site to create activated carbon that can be injected directly into flue gas to adsorb mercury upstream of the particulate control device. Demonstrated to be effective with lignite, subbituminous coals, and bituminous coals, the process can prepare forms of activated carbon that have various surface areas, pore structures, and surface chemistries.

Tests have shown that the technology can produce activated carbon for less than half the cost of purchased carbon. A 500-megawatt plant could save $0.5 million–$2.5 million annually, and cost savings for the utility industry could exceed $500 million per year.

Field Tests Confirm Product Quality

Laboratory testing showed that the sorbent activation process can produce activated carbon with properties comparable to those of products sold commercially for mercury control. A unit producing 50 lb/hr was tested at Ameren's Meredosia power plant in Illinois. Two weeks of phase I testing showed the feasibility of generating activated carbon from pulverized coal and identified issues that could potentially result in low yields and carbon products with low surface area once the technology is scaled up. These issues were addressed in phase II testing.

While the samples produced in phase II were equal in adsorption capacity to commercial activated carbon, they received only limited testing in the flue gas at Meredosia because the boilers were off line for extended periods. Trials were continued in full-scale tests at Dynegy's Hennepin plant in Illinois.

Full-scale prototype sorbent activation unit, installed at a power plant.

Prototype Performs Well

The testing at Hennepin on a 75-megawatt (electric) unit equipped with a Toxecon fabric filter and firing Powder River Basin coal confirmed that activated carbon produced by the sorbent activation process performed comparably to commercial products. Both Powder River Basin coal and Illinois bituminous coal were used as feed for the test, with the products achieving ~85% mercury removal across the fabric filter when injected at 1.4–1.8 lb/MMacf (million actual cubic feet) of flue gas. A commercial activated carbon achieved only 75% at an injection rate of 1 lb/MMacf.

Researchers also experimented with adding calcium bromide to coal entering the boiler, a technique for enhancing mercury removal that EPRI is evaluating in related research (see "Southern Company Evaluates Mercury Control Technologies," page 30). This approach boosted removal levels to 92% in the case of Powder River Basin coal. Results from the Hennepin trials were considered very encouraging, given that the tests were performed with a prototype sorbent activation process unit that had not been refined for optimal performance.

Future Work

The next step is to build a full-scale unit for long-term performance and cost evaluation at a power plant. The new unit will build on the design experience gained from the prototype and recent test trials, and its refinement will be guided by a team that includes a commercial burner company and a collaborative of power-generating companies. Design, fabrication, and installation of the new unit are planned for 2010, and testing is expected to be conducted at two to three power plants for 3–6 months in 2011 and 2012.

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