Wireless Sensor Network for Electric Transmission Line Monitoring

Project Fact Sheet

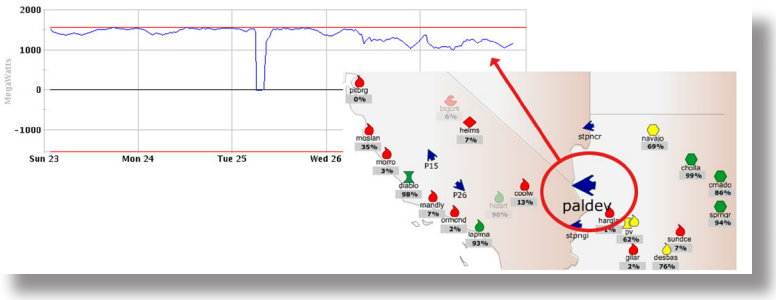
The focus of this technology research and development project is to address the lack of information available to Federal Agencies regarding grid status for use during actual or potential grid emergencies.

The National Energy Technology Laboratory (NETL) is managing this and other electric grid R&D projects on behalf of the DOE Office of Electricity Delivery and Energy Reliability (OE).

Goals

Building upon Genscape's infrastructure for power plant monitoring, and University of Louisville's research expertise in sensor technology this project seeks to:

- Develop real-time electric transmission line monitoring technology optimized for large scale, low cost deployment.
- Improve transmission line sensing capabilities in high density, urban areas.
- Obtain electric power line (or grid) information in real time independent of owners/operators of grid assets.
- Provide a source of information that Government can use to obtain situational awareness of the electrical grid.



Loss of transmission line power flow detected, Palo-Devers 500kV line

How Does it Work?

At present, Genscape Inc.'s commercially owned and operated power line monitoring network wirelessly monitors the magnitude and direction of power flow on lines flowing into and out of power plants. Power information is determined by using a non-contact technique to determine the electromagnetic field emanating from the lines. Currently, 1200 transmission lines entering and leaving 400 of the larger US power plants are monitored.

To provide real time detailed awareness of the entire electrical grid, this network must be greatly expanded, and its capabilities enhanced. This requires that the existing power monitors be re-designed to optimize their form factor, functionality, and cost. With the monitor power source being a major contributor to the monitor size and maintenance needs, research on alternative power sources is being done to explore the possibility of scavenging the power needed for sensing and wireless communication. Power sources available for scavenging include the electric and magnetic fields emanating from the power lines themselves, or in urban settings, the mechanical vibrations due to nearby noise sources. For vibrational energy scavenging, an innovative magnetically modulated cantilever design is being implemented, providing greatly improved efficiency.

For the monitor processor, the Crossbow Mote TelosB Research Platform is being implemented, thereby reducing size, cost, and power consumption. For sensing, the large magnetic solenoid used in the present monitors is being replaced with a 3-axis magnetic field sensor chip. This provides improved awareness of the direction of the magnetic field vectors, which allows specific transmission lines to be targeted in the presence of other nearby lines through computational decomposition of the magnetic field readings.

Team:
University of Louisville

Genscape Inc.

Period of Performance:
9/2006 – 9/2007

Cumulative Project Funding:
Non-DOE: $459,495 (33%)

DOE: $950,000 (67%)

Total: $1,409,495

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Links:
University of Louisville:

http://www.louisville.edu

Genscape:

http://www.genscape.com

Office of Electricity Delivery and Energy Reliability:

http://www.oe.energy.gov

NETL:

www.netl.doe.gov

MGI:

www.netl.doe.gov/moderngrid

Field tests of the prototype monitors are being performed at four test sites, each chosen to demonstrate the monitor capabilities under a different set of conditions—variable magnetic field, variable electric field, vibrational power source, and high line density. Data processing algorithms are under development to process the new monitor data types and a transmission line visualization interface is being created to provide real-time transmission line data. Finally, the possibility of integrating the data with existing SCADA and EMS systems (in collaboration with E. ON US -Louisville Gas and Electric) and disseminating the data to federal agencies and utilities is under investigation.

What are the Benefits?

Information concerning the real time status of the electrical grid is typically only available to those with an ownership, operating, or reliability responsibility for those assets. This information is seldom made available to other stakeholders with an interest in the status of the grid. The result is that federal agencies such as the Department of Energy have had very limited success to date in obtaining relevant grid information from the electrical sector. This project provides a source of information that the Government can use to obtain a situational awareness of the electrical grid.

What are the Primary Applications?

The primary application is to provide an electrical grid "situational awareness" during and prior to grid "emergency" situations (e.g., potential or actual grid brownouts/blackouts whether due to general system operational events or non-system events –such as hurricanes, earthquakes, fires or sabotage). Without a better situational awareness of the electrical grid in these instances, the ability of the Government to effectively assess and react to these situations can be significantly impaired. This capability is important to assist Federal Agencies such as DOE in performing mission related functions during actual or potential grid emergencies. The research being done on energy scavenging will have applications beyond the primary goals of this project, to include any situation where power is needed for sensing and wireless communication.

Wireless non-contact transmission line monitor detects electromagnetic fields from the line.

What are the Status and Accomplishments to Date?

- Research in vibrational energy scavenging has shown large increases in power scavenging efficiency by using a magnetically coupled cantilever.
- A 3-axis magnetic field sensor has been demonstrated for use to measure power flow through a transmission line lying in close proximity to other lines.
- The Mote processor interface hardware has been developed and interfaced to existing sensors and power sources; the magnetic and electric field reading applications have been implemented in TinyOS.
- The functionality of a data visualization scheme for transmission line alerts based upon Google Earth has been demonstrated.

What is the Market Potential?

The real time global grid information provided by this monitoring technology will help government agencies and utilities during the emergency assess and quickly repair damage to the grid, and provide data to prevent emergency situations from escalating into blackouts. The market potential lies in the untold amount of time and resources that would normally be expended on grid assessment and repair, or lost to commerce when the grid shuts down.