Advanced Sensor Development

CHALLENGE

To assess the grid's health in real time, predict behavior and potential disruptions, and quickly respond to events, increased situational awareness of the nation's electric system is critical. Without accurate information, it is difficult to operate the system reliably, and this problem has contributed to large-scale power disruptions and outages in the past. Although more observation points have been deployed with recent investments (e.g. smart meters, phasor measurement units [PMUs]), very little visibility is currently available at and below the distribution level, thereby limiting the integration of distributed systems and utilization of loads to their full potential, because you "cannot control that which you do not know."

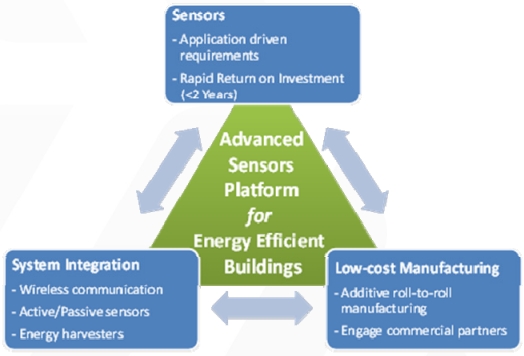

Illustration of an advanced end-use sensor.

From a systems perspective, this challenge can be broken down into three primary areas:

- End Use – Utilities must be aware of consumption needs and a means of effectively managing demand while operating within safety and occupant constraints.
- Transmission and Distribution – Ever-increasing fast transient swings in the future grids with predominant power converter-based generation and load are not well captured by the existing sensors.
- Asset Monitoring – Current sensing platforms are expensive and not broadly applicable across the entire current and future grid asset monitoring spectrum.

APPROACH

End-use – Heating, ventilation, and air-conditioning (HVAC) systems account for approximately 50% of the building load and have untapped dispatch potential. Project objectives in this area are to 1) develop low-cost sensors, exploiting additive manufacturing techniques, to monitor the building environment and electrical characteristics of HVAC equipment; and 2) develop algorithms to use building-level data to provide utility-scale visibility of grid reliability and localized weather monitoring.

Transmission & Distribution – At the transmission level, this project will develop advanced phasor measurement unit (PMU) algorithms for ultra-

At-A-Glance

PROJECT LEADS

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PARTNERS

- University of Tennessee
- SmartSenseCom
- Electric Power Research Institute
- Genscape
- Southern Company
- TVA
- ComEd
- EPB
- National Instruments

BUDGET

$2.41 million

DURATION

April 2016 – March 2019

TECHNICAL AREA

Sensing and Measurements

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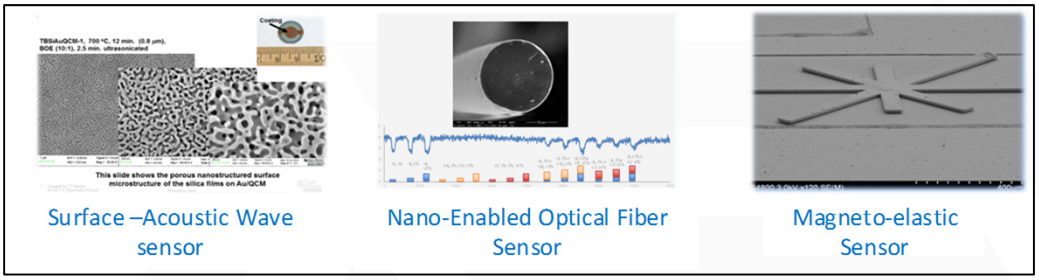
fast transient measurement during disturbances. This project will integrate PMU algorithms into optical transducers for high-accuracy and wide dynamic range monitoring. The ultimate objective is to achieve transient stability prediction and control during the critical first swing.

Asset Monitoring – DOE's national laboratory system is uniquely capable of developing and demonstrating broadly applicable sensing platforms in partnership with industry and other strategic partners. These highly diverse platforms can be functionalized for a broad range of parameters of interest spanning temperature, chemistry, magnetic field, voltage, etc., through a combination of device design and integration with engineered functional sensing materials. At the same time, the cost of sensors will be reduced by at least an order of magnitude compared to the current state-of-the-art.

Advanced sensor development for asset monitoring.



EXPECTED OUTCOMES

By understanding vital parameters throughout the electric infrastructure, from generation through end-use, utilities will be able to assess grid health in real time, predict behavior and potential disruptions, quickly respond to events, and better address future challenges. Specific outcomes in each area include the following:

- **End-use** – Development of low-cost sensors and additive manufacturing techniques to monitor the building environment and electrical characteristics of HVAC equipment, and algorithms that use building-level data to provide utility-scale visibility of grid reliability and localized weather monitoring.
- **Transmission & Distribution** – Increased resolution of transmission grid visibility beyond current technologies. Progress will be made in dynamic response and data resolution as well as innovative ways to estimate electrical parameters from optical sources.
- **Asset Monitoring** – Sensing platforms with attributes that are best-suited for broad applicability across the entire current and future grid asset monitoring application space.

LAB TEAM

BERKELEY LAB | NATIONAL ENERGY TECHNOLOGY LABORATORY | NREL NATIONAL RENEWABLE ENERGY LABORATORY | OAK RIDGE National Laboratory | Pacific Northwest NATIONAL LABORATORY | Sandia National Laboratories

Launched in November 2014 under the U.S. Department of Energy's Grid Modernization Initiative, the GMLC is a strategic partnership between DOE Headquarters and the national laboratories, bringing together leading experts and resources to collaborate on national grid modernization goals. The GMLC's work is focused in **six technical areas** viewed as essential to modernization efforts:

Devices and Testing | Sensing and Measurements | Systems Operations and Control
Design and Planning | Security and Resilience | Institutional Support