SENSORS & CONTROLS

OVERVIEW

This research area is making available new classes of sensors and measurement tools that manage complexity; permit low cost, robust monitoring; and enable real-time optimization of fully integrated, highly efficient power-generation systems. Controls research centers on self-organizing information networks and distributed intelligence for process control and decision making. Networking of sensors and the use of wireless communication technologies promote the reliability of these systems. These new technologies are designed to benefit both existing and advanced power systems such that meaningful improvements can be made in efficiency and availability. As generational and transformational systems mature, sensors and controls will serve as an essential and enabling technology to operate these systems under conditions where optimal performance is balanced with reliability. Alongside the sensors and controls efforts, users need to make and implement decisions and derived optimizations in real time. This capability will be attained through new computational tools that can match sensor data and analytical inputs to decision-making assistance and controls actuation.

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Sensors and Controls research is focused on sensors capable of monitoring key parameters (temperature, pressure, and gas compositions) while operating in harsh environments, and analytical sensors capable of on-line, real-time evaluation and measurement. Controls development centers around self-organizing information networks and distributed intelligence for process control and decision making.

The Sensors and Controls project portfolio is categorized into these component technology areas:

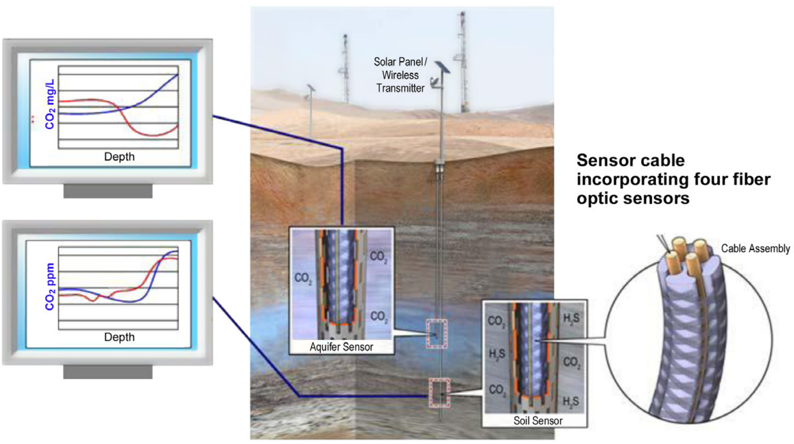
Advanced Sensors

- Optical Sensors, Microsensors, Wireless Sensors, Embedded Sensors, Novel Sensor Concepts

Distributed Intelligent Controls

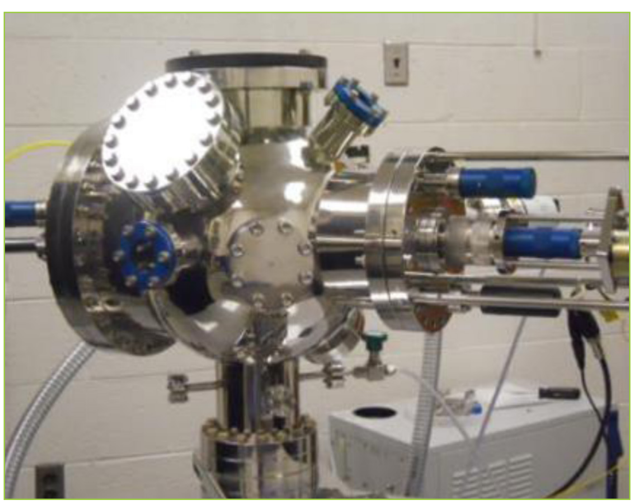
- Advanced Process Control, Sensor Placement and Networks

These new technologies are designed to benefit both existing and advanced power systems by enabling meaningful improvements in efficiency and availability. As generational and transformational systems mature, sensors and controls will serve as an essential technology to operate these systems under conditions where optimal performance is balanced with reliability. Alongside the sensors and controls efforts, users require the ability to make and implement decisions and derived optimizations in real time. This capability will be attained by new computational tools that can match sensor data and analytical inputs to decision-making assistance and controls actuation, resulting in desired outcomes.



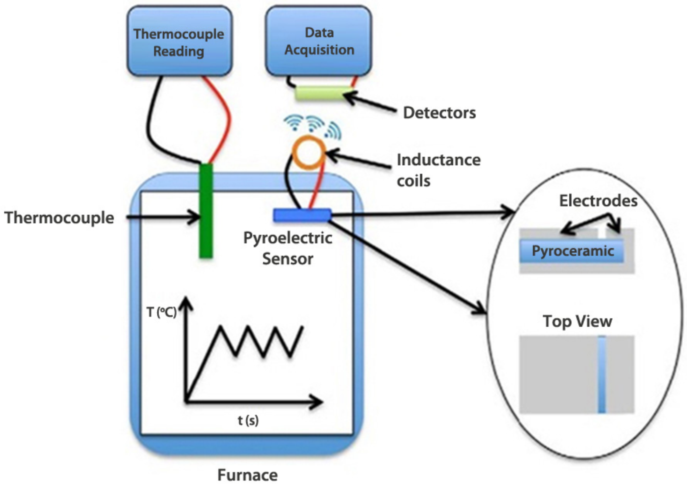
OPTICAL SENSORS

Optical sensing includes a range of sensing devices for real-time measurement of temperature, pressure, strain/stress, and gas species. Approaches range from non-contact, laser-based techniques to novel fiber-optic sensor designs. Development efforts within this area include functioning under extreme environments, designs for multiplexing and distributed measurements, approaches for low-cost devices, materials for fiber coatings, optically active smart coatings, and packaging the sensors for commercial application.



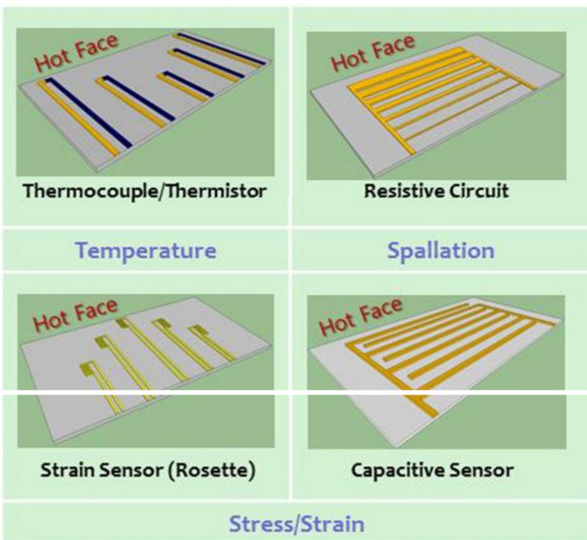
MICROSENSORS

The microsensor technology area encompasses a significant research effort to develop materials and structures to enable sensing at elevated temperatures (greater than 500 °C). Targeted measurements include detection of a suite of gases, as well as temperature, pressure, strain/stress, corrosion, and other component condition assessments. Primary challenges with microsensors center on the selectivity and accuracy of devices with respect to a specific parameter (e.g., concentration of a particular gas) or suite of simultaneous measurements. This area includes sensing devices that can be made wireless, integrated with self-powering capability, and/or embedded within a component. Recent efforts in this area include the development of sensors that are low cost and can be rapidly prototyped with advanced manufacturing techniques. The culmination of this work will be robust, low-cost sensors that can be rapidly produced for wide distribution within an industrial environment.



WIRELESS SENSORS

Components and machinery for fossil-energy-based energy systems require meaningful measurements and data from locations where wired technologies are not feasible or practical. Technologies currently under development include methodologies for wireless signal transfer at stand-off distances under various harsh-environment conditions as observed in boilers, gas turbines, and other fossil energy applications.

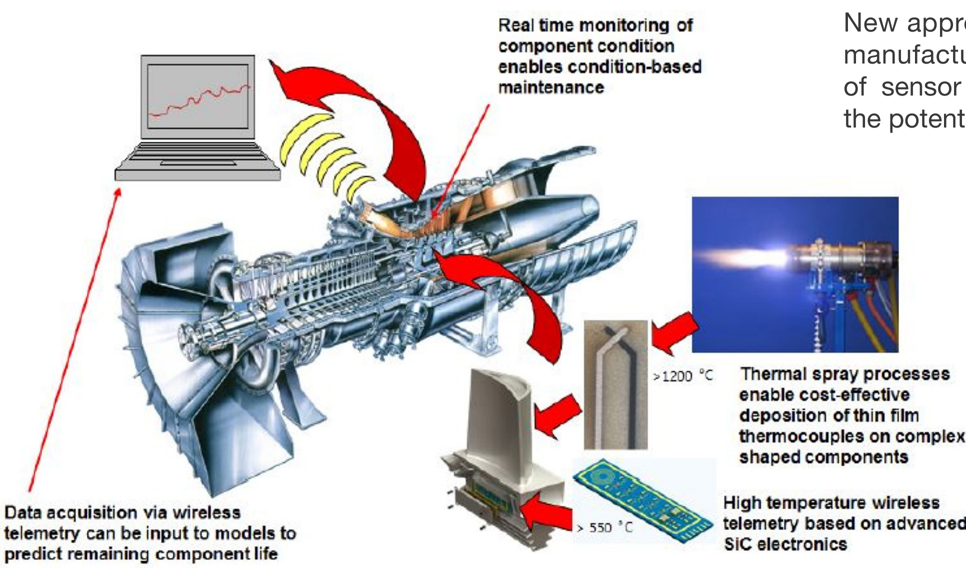


EMBEDDED SENSORS

Embedded sensors allow for increased durability and reliability by removing sensor elements from direct exposure to the harsh operating environments encountered within fossil-energy-based energy systems. Projects within this section feature advanced manufacturing and fabrication techniques for embedding sensor elements into components. Embedded sensors allow for advanced structural health monitoring over component lifetime and also process control to increase system efficiency.

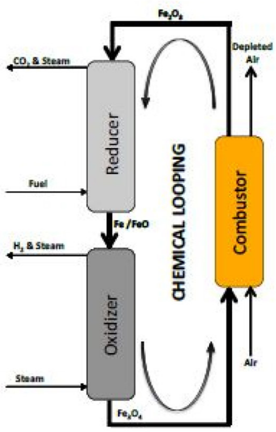
NOVEL SENSORS CONCEPTS

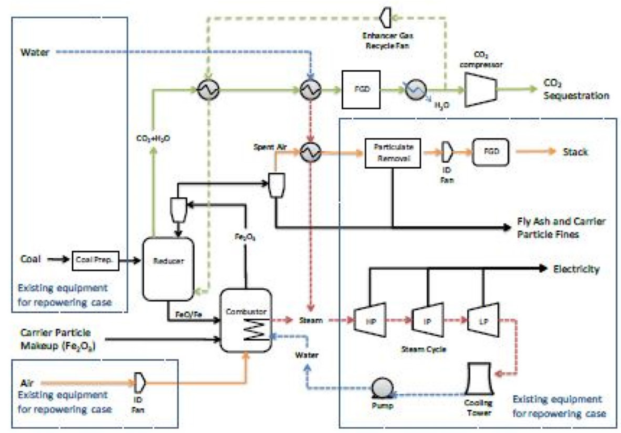
New approaches to sensing technologies and to manufacturing (e.g., of smart parts) and utilization of sensor data (e.g., imaging/visualization) have the potential to be transformative.



ADVANCED PROCESS CONTROL

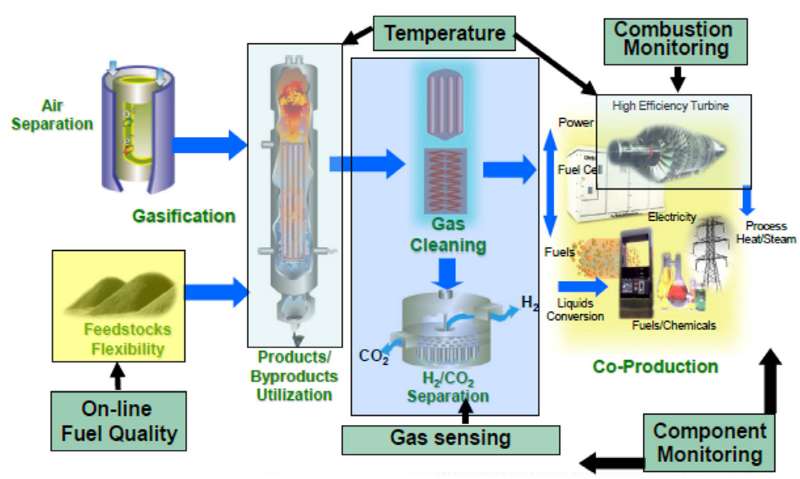
Dynamic process modeling encompasses computational efforts to represent physical systems and processes by developing and implementing high-fidelity models using real-time data as input. High-fidelity models are reduced and configured to run in real time (second time scales) to represent the dynamics of the operating system. Using reduced and speedy models in conjunction with estimation algorithms and other types of predictive algorithms, an overall control solution can be derived to enable model-based control for real-time process control. This general approach is well understood for linear and steady-state systems. Research within the Sensors and Controls key technology area adopts these approaches but incorporates new approaches that have the ability to develop control systems with fast dynamics for nonsteady-state and incorporate controls that are capable of handling systems that are inherently nonlinear. Accomplishing these developments, with real system validation, provides significantly increased control compared with that of traditional proportional-integral-derivative control and is more robust than linear model predictive control algorithms.





SENSOR PLACEMENT & NETWORKS

This transformational effort attempts to unify and apply a wide range of novel computational and measurement approaches to derive value and improve operation and control of complex systems. This research focus area encompasses novel computational approaches to optimize sensor placement for various objectives (e.g., performance, fault management, cost) and to enable cognitive capability within sensing and actuation components such that intelligence can be distributed within a control architecture. This distribution of intelligence, coupled with self-organization of actuation and sensing devices, offers a robust approach to managing fast dynamics and large amounts of data/ information, and it addresses the need to make many decisions in millisecond time scales for a large and highly integrated power system with carbon capture. Measures for this area include the correct identification of algorithms and architecture to permit novel approaches to be combined and operated as a unified system. NETL has developed simulation tools and a hardware-based test bed to evaluate concepts and to provide a platform to assess the value of these breakthrough concepts.



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