

commercially relevant conditions of temperature and pressure. Experimental studies should include analytical methods such as XRD, SEM, TEM and pressure-composition isotherm measurements to determine the phase purity, microstructure and hydrogen absorption characteristics. The investigations should aim to optimize the hydrogen absorption characteristics, such as the amount of hydrogen absorbed, the plateau pressure and kinetics by modifying the composition of the material and its microstructure.

Sensors and Control

DOE/NETL's Advanced Research Program is aimed at bridging the gap between the basic sciences and applied research as it relates to fossil energy applications. One area in which this transitional fundamental type research is needed is in the area of novel high temperature materials that can be used in the fabrication of miniaturized in-situ sensing devices for the measurement of various gas species.

Available sensors for measuring gaseous emission of CO, CO₂, HC's, Hg, H₂S, NO_x, etc. cannot withstand the high temperature, hostile environments found in advanced fossil energy systems. Experimental research projects are sought for the development of materials suitable for the production of low cost disposable sensors which can be used in a "plug and play" fashion for the detection of various fossil fuel gases under high temperature (>500 °C) and high pressure (200 psi) conditions. Fundamentally-based research programs focused on new materials (including material matrices, functionalized or coated substrates, doped ceramics, nano derived micro structures) such that the bulk properties of the material can be utilized in miniaturized devices with sensing characteristics at high temperature are encouraged.

The long term envisioned use of the materials will be to fabricate low cost micro sensors that can be used and easily replaced after 180–360 days of exposure to the harsh conditions found in ultra clean fossil energy applications. Hence the promising candidates identified as a result of this fundamental research will be explored to address cost associated with the development and fabrication processes that would provide sensing devices for commercial applications.

While revolutionary ideas that have the sound scientific basis to support significant advancements in this area are sought, experimental studies with material systems in which the sensing properties are understood are discouraged.

Measurement and Technology for Gasification

To sustain our nation's economic growth, utilization of our most abundant fossil energy resource, coal, in an efficient and environmentally responsible manner is needed. Consequently, the DOE is supporting the development of advanced technology power plants that offer higher efficiency, lower emissions, and reduced capital and operating costs. Gasification technologies are key to addressing several of the advanced technologies issues of clean production of electric power, hydrogen for the new "hydrogen economy," and industrial chemicals or refined fuels while reducing the impacts on water resources, solid waste disposal, and capturing carbon dioxide (CO₂) that is generated in the use of fossil fuels. To meet the demands of the Hydrogen Initiative, the requirements for fuel cell and advanced turbine power units, and to meet the increasingly stringent environmental regulations, the synthesis gas produced by gasification will need to be cleaned to tighter specifications. At the same time, the gasification and gas cleanup processes will need to have reduced costs, improved reliability, and the ability to be readily integrated for increased efficiency. These improvements will enable the integration of advanced concepts for high-efficiency power generation and pollution control into a class of fuel-flexible facilities capable of operating with near zero environmental emissions. Based on gasification, there are a variety of configurations to meet differing market needs, including both distributed and central generation of power. The development and optimization of advanced coal gasifiers will be critical to the success of this program. This topic seeks to develop key support technologies and measurement techniques for these gasifiers. Grant applications are sought only in the following subtopics:

a. Advanced Refractory Systems for Gasification Systems

Refractory liners in high temperature slagging gasifiers are known to undergo significant deterioration over a relatively short period of time, requiring considerable maintenance. Depending upon the operating temperature of the gasifier, plant size, and the feedstock, refractory liners last only 6–18 months and cost over \$1 million in materials, manpower, and lost revenues to replace. Therefore grant applications are sought to develop advanced refractory systems or new materials with an expected

useful life of three or more years. Of particular interest are materials with the ability to withstand multiple feed stocks such as coal, biomass, and petroleum coke, and materials that contain no chromium.

b. On-Line Flow and Composition Measurements for Gasification Systems

The ability to measure, control, and quickly respond to fluctuations in the flow quantities and composition of feed streams to gasifiers and in the synthesis gas product stream can be crucial to maintaining performance to design standards and keeping the production of gasifiers on-stream at high capacity factors. Real-time and on-stream measurements are likely to be helpful in identifying systems upsets and responses to protect downstream equipment. Grant applications are sought to develop robust on-line measurement and control systems for (1) feeding abrasive and eroding solids across pressure barriers to 1000 psi into gasifiers, and for (2) product synthesis gas streams at high temperatures (to 2500 °F) and high pressure (to 1000 psi) laden with aggressive particulates. Gasifier feeds are typically water slurries with loadings of 50 to 70% solids, or pneumatically fed dry pulverized solids. The feed may contain coal, pet coke, coal-pet coke mixtures (typical 50–50%), water as slurry agent, or biomass (typically 10–20%). On-line measurements of feed quantities and composition should address attributes such as particle size distribution, particle loading, coal/pet coke/biomass composition changes, and amount of water. The synthesis gas product will typically contain bulk constituents (CO, CO₂, H₂, H₂O, CH₄), major contaminants (H₂S, COS, NH₃, Cl), and trace contaminants (Hg, As, Se, V, Ni). On-line measurement of any or all of these constituents at gasifier exit conditions of high temperature and pressure will enable more direct control of the operation of the gasifier.

c. Novel CO₂ and/or Hydrogen Separation Technology

One vision of clean energy in the future is to make hydrogen from coal in an ultra-clean production plant. In this vision, coal is gasified using oxygen, and the resultant syngas (mostly CO, H₂ and H₂O) is then turned into a stream of predominantly H₂ and CO₂ through the water-gas-shift reaction. The purpose of hydrogen separation technology is to economically transform this mixed gas into two pure streams: One of H₂, and one of CO₂. The mixed gas stream is expected to be 450–500 °F and 300 psi. Most current projects in