# Solid Oxide Fuel Cells for Coal-Based Power

The Solid State Energy Conversion Alliance (SECA) program will provide the technology for future coal-based fuel cell power plants, as shown in Figure 1—a concept of a FutureGen plant that supports an efficient and clean hydrogen and electric economy. Before this technology can be achieved, however, improved understanding of how SECA technology will perform under coal syngas is needed. This project performs research that identifies the effects of coal contaminants on fuel cell operation.

The specific objectives for this project are as follows:

- Test solid oxide fuel cells (SOFC) button cells on simulated coal syngas to generate performance data and model validation data.
- Test current SOFC technology for the effects of syngas trace species.
- Develop models specific to anode transport of coal syngas.
- Develop models predicting rates of degradation upon exposure to various contaminant species.
- Investigate methods to mitigate coal contaminant gas effects.
- Test SOFC cells directly on gasified coal to assess the performance of today's SOFC technology.

*Figure 1. Future Gen*

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## NETL Onsite Research

Researchers at the National Energy Technology Laboratory (NETL) recently completed analysis of degradation for SOFC composed of typical materials exposed to typical syngas components including benzene, naphthalene, and mercury. Temporal performance data are shown for 500 parts per million naphthalene exposure in figure 2, and indicate a slightly accelerated degradation rate relative to a cell fueled with hydrocarbon-free syngas. Figure 3 shows a mobile SOFC test skid containing a parallel array of 12 fuel cells, which can be interfaced with a coal gasification facility to receive direct syngas. The parallel fuel cells are depicted in figure 4. The test skid (called the SOFC MCA) was recently operated at the NCCC/PSDF gasification facility in Wilsonville, AL, for 450 continuous hours. It generated over 4,500 cell-hours of data and produced in excess of 1 kilowatt over the course of the test. To support analysis of trace elements contained in the gas phase, NETL researchers also operate an analytical device capable of detecting trace metals with part-per-billion sensitivity. The mobile device, called a GC-ICP/MS, is pictured in figure 5. The uniquely configured and operated GC-ICP/MS produces trace and ultra-trace metal analysis in minutes, whereas conventional methods for similar analysis typically require more than six hours. A typical trace is shown in figure 6, and shows the isotopic fingerprint of mercury.

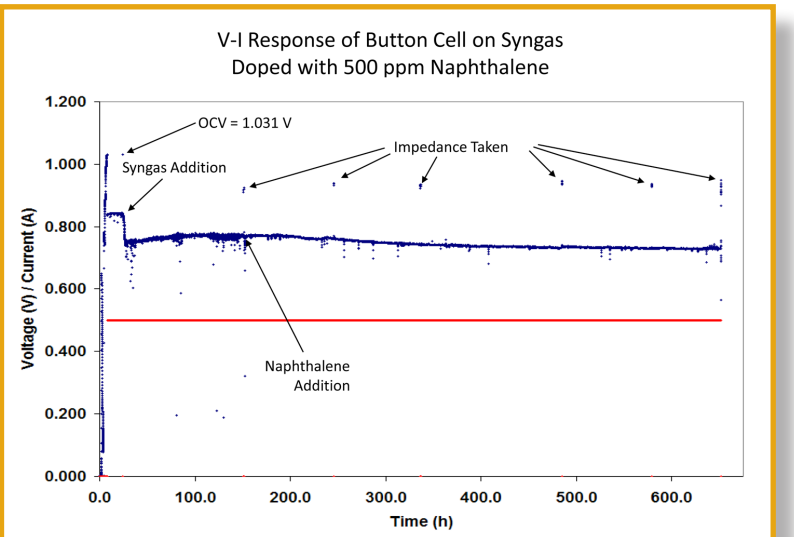


*Figure 2. Voltage/current output for cell exposed to syngas with 500 ppm naphthalene contaminant.*

*Figure 3. NETL researcher Rich Pineault makes final connections to SOFC MCA installed at NCCC/PSDF gasification facility in Wilsonville, AL.*

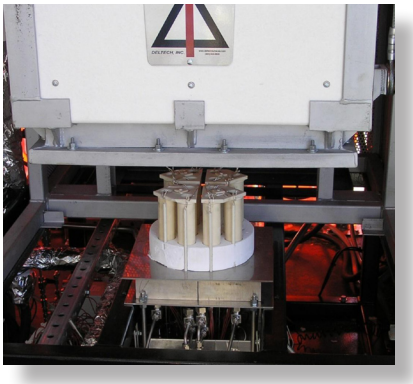

*Figure 4. Installed fuel cell test unit depicting layout and design of 12-cell parallel array.*

*Figure 5. The GC-ICP/MS system can achieve better than part-per-billion sensitivity and analyzes samples in minutes.*

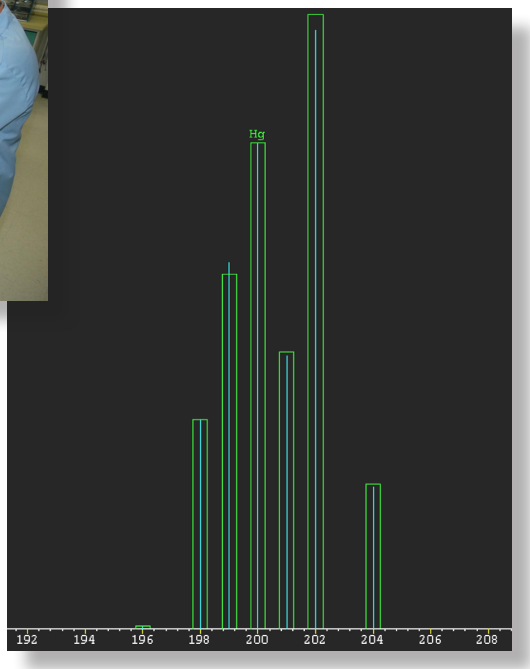


*Figure 6. Typical GC-ICP/MS trace of mercury (Hg) showing accurate identification of relative isotopic abundance.*

## Opportunities

These experimental facilities are used in collaboration with West Virginia University (WVU), University of Pittsburgh (Pitt), and Carnegie Mellon University (CMU) to expand and speed NETL work in SOFC fuel cells. Work includes determining the effect temperature and syngas exposure to relative grain orientation within the cathode (Prof. Salvador/CMU, PI), and development of methods for determining the electrical conductivity of cell materials (Prof. Xingbo Liu/WVU, PI). NETL continually seeks collaborators that are interested in advancing SOFC technology for coal-based power applications.