HYBRID PERFORMANCE PROJECT

NATIONAL ENERGY TECHNOLOGY LABORATORY

Research programs initiated by the U.S. Department of Energy (DOE) to achieve increased efficiency, improved flexibility, and reduced emissions are expected to result in the development of highly integrated or hybrid power generation technologies that are clean and use far less fuel to produce the same power as technologies used today. This highly efficient and flexible technology would extend our natural resources reducing the dependence of the United States on foreign sources of oil and other energy feedstocks and provide resiliency with respect to the continued penetration of intermittent renewable power resources such as wind and solar. No single technology is capable of meeting the aggressive efficiency and flexibility targets proposed by DOE programs, which emphasize the need for research in systems integration and controls.

As an example, one technology identified with the promise of meeting such a challenge is the combination of a high-temperature fuel cell and a gas turbine with a gasifier or reformer. This hybrid technology has been studied extensively through the use of numerical models and a limited number of demonstration projects. The Hybrid Performance Project (Hyper) was initiated by DOE's National Energy Technology Laboratory (NETL) to make this complex integration work. In subsequent years, the scope of the Hyper project was expanded to include support for other innovative energy technologies as a test bed for new sensors and advanced control methods that could improve the performance of existing power plants.`

CAPABILITIES

Developing an understanding of dynamic issues related to the coupling of several novel power generation, thermal processing, and energy storage technologies is critical to the design of commercial equipment. Likewise, evaluation and testing of control strategies is critical to the implementation of commercial equipment. An experimental test facility was designed and built at NETL's Morgantown site as a resource for researchers and industrial developers of hybrid power systems. The facility is the only one of its kind anywhere in the world.

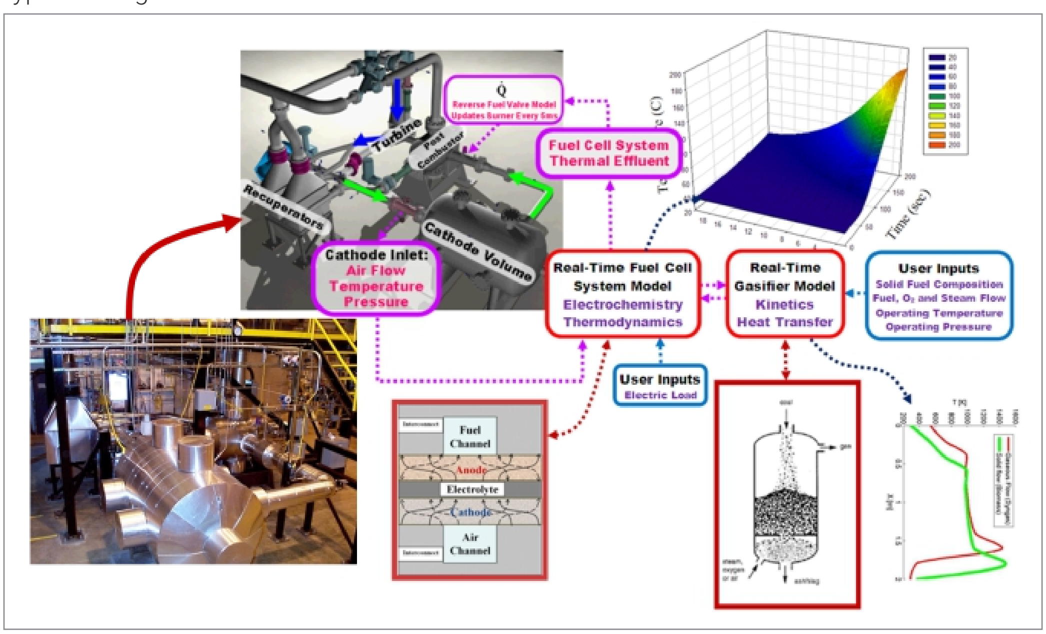
The experimental facility simulates more expensive and developing technology, such as a fuel cell and gasifier, thermal energy storage, or even concentrated solar power, through a combination of hardware and software known as a "cyber-physical system" in the literature. This hardware, used for simulating the developing technology (pressure vessels, piping, and a burner), is coupled to heat exchangers, a turbine and compressor, control valves, a generator, and a continuously variable load bank in order to evaluate the dynamics of a fully integrated system.

The cyber-physical approach allows control strategies to be developed and tested before actual implementation of the technology, reducing risk associated with pilot-scale exploration. It also provides opportunities for feedback from the pilot scale to materials development that could impact system performance. For example, a variety of fuel cell types and geometries can be tested without risk to such an expensive component of the system. In determining the operating boundaries of a fuel cell-turbine hybrid system, preliminary tests would have resulted in the destruction of many fuel cells, but opportunities in system flexibility have been realized. Research using the facility has identified control methods enabling extensive turndown capabilities, fuel composition flexibility, and even a potential ten-fold increase in component lifetime. A diagram of the Hyper cyber-physical system concept is shown in the figure below.

The test facility was designed to isolate and independently instrument each component of the system and is capable of simulations for systems up to approximately 1MW. Recently, an independent heat source was added for cyber-physical simulations to allow supplementary firing as a turbine speed control method. This additional capability enables the facility to explore load-following for peaking demands, as well as distributed power applications, improving grid reliability during transient events during power demand fluctuations or generation intermittency from renewable assets. The addition of dSpace and OPAL RT simulators has expanded the capabilities of simulation to include spatial resolution of l cell and gasifier components in real time.

OPPORTUNITIES

The Hyper experimental facility and modeling results are available for public research collaboration with universities, industry, and other research institutions. In addition to planned NETL studies, the Hyper facility is intended to provide a test platform for novel sense and control strategies that may emerge from university or small business research projects. Collaboration with academic, non-profit, or commercial research groups can be arranged under a variety of cooperative programs, such as a cooperative research and development agreement, and student or visiting scholar programs. There are currently four international and many domestic academic collaborations underway, as well as three industrial collaborations.



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