Project Summary

Project Title:	AOI 3 – Low Cost High-H_2 Syngas Production for Power and Liquid Fuels
Principal Investigator:	Dr. Shaojun Zhou, Gas Technology Institute (GTI
Solicitation Number:	DE-FOA-0000784

Objectives: The overall objective of this project is to determine the technical and economic feasibility of a systems approach for producing high-hydrogen syngas from coal that has the potential to significantly reduce the cost of producing power, hydrogen or liquid fuels with carbon capture and reducing the environmental impact of gasification. For the technology to be ready for first-of-a-kind commercially relevant demonstration by 2030: laboratory studies will establish the proof of concept of a novel metal-polymeric membrane; additional critical design data will be obtained for an integrated multi-contaminant removal process; and techno-economic analyses will integrate these technologies with a Pratt & Whitney Rocketdyne (PWR) gasifier, using coal co-fed with natural gas, for the power, hydrogen, and liquid fuels and compared the systems with current hydrogen from coal technologies.

Brief description of technology proposed methods to be employed:
A mixture of coal and natural gas (with >50% of the total energy from coal) would be first converted to syngas in the PWR gasification reactor. The natural gas will increase the hydrogen content of the syngas. The produced syngas will go through a series of conventional processing steps such as quench, water gas shift, and cooling depending on the end use of the hydrogen. GTI's UCSRP-HP will use co-current static mixing reactors to scrub heavy metals, ammonia, and chlorides from the syngas and then react hydrogen sulfide in the syngas with added sulfur dioxide in the presence of a solvent/homogeneous catalyst to form liquid elemental sulfur plus water. For the proposed GTI hydrogen membrane, a thin, hydrogen-perm selective, a metal layer would be deposited on a high specific surface-area, porous, hollow fiber (e.g., polybenzimidazole [PBI]). A flowing, cooling liquid inside hollow fibers would sweep hydrogen from the membrane surface while maintaining the membrane temperature at a suitable range required for the polymer substrate. The effluent hydrogen/cooling-liquid mixture would be flashed to recover pure hydrogen at a relatively high pressure minimizing compression for turbines, pipelines, or liquid production plants. The retentate carbon dioxide rich stream would also be produced at near the feed gas pressure, thereby minimizing downstream compression for sequestration or EOR use.

Potential impact of project benefits and outcomes:
GTI will conduct preliminary conceptual designs and techno-economic analyses to estimate cost of products and environmental performance for IGCC, chemical-grade hydrogen, and production of diesel involving integration of the novel hydrogen membrane and the UCSRP-HP technologies into a PWR gasification system co-gasifying coal plus natural gas. The advantages of the proposed concept over conventional gasification technologies include:

- PWR gasification technology: Best-in-class gasification process for power and hydrogen production with conventional technologies. 13-25% lower cost with conventional technology.
- High purity, high-pressure hydrogen: Minimal purification required, delivered at turbine, pipeline or liquids production pressures.
- CO_2 sequestration ready: CO_2 produced at near gasification pressure.
- Near-zero emissions from the proposed process: Integrated H_2S/trace-components removed.
- Compact simple equipment: Process intensification with compact gasifier, integrated processes and high surface area hollow fibers. No moving/circulating solids at high pressures in the syngas treating system.
- Flexibility: plant systems can be optimized for power, chemical hydrogen, or liquid fuels.
- Efficiency: Large temperature swings are minimized.
- Lower cost: Capital and operating costs will be significantly lower for hydrogen, electricity, and liquid fuel. GE Energy gasifier, UCSRP-HP and hydrogen membrane at least competitive with RTI and hydrogen membrane for power generation before advantages of PWR considered.