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Intermediate-Sized Natural Gas Fueled Carbonate Fuel Cell Power Plants,
CRADA 93-013, Executive Summary

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This executive summary of the report "Intermediate-Sized Natural Gas Fueled Carbonate Fuel Cell Power Plants," describes the accomplishments of the joint U.S. Department of Energy's (DOE) Morgantown Energy Technology Center (METC) and M-C POWER Corporation's Cooperative Research and Development Agreement (CRADA) No. 93-013.

This study addresses the intermediate power plant size between 2 megawatt (MW) and 200 MW. A 25 MW natural-gas, fueled-carbonate fuel cell power plant was chosen for this purpose. In keeping with recent designs, the fuel cell will operate under approximately three atmospheres of pressure. An expander/alternator is utilized to expand exhaust gas to atmospheric conditions and generate additional power. A steam-bottoming cycle is not included in this study because it is not believed to be cost effective for this system size.

This study also addresses the simplicity and accuracy of a spreadsheet-based simulation with that of a full Advanced System for Process Engineering (ASPEN) simulation. The personal computer can fully utilize the simple spreadsheet model simulation. This model can be made available to all users and is particularly advantageous to the small business user.

The carbonate fuel cell performance model used in this study is based on state-of-the-art M-C POWER Molten Carbonate Fuel Cell (MCFC) Technology. The fuel cell performance and output voltage are supplied by CRADA protected M-C POWER power-block models. ASPEN simulations using these inputs were developed by DOE/METC, and compared to independent system simulations conducted by M-C POWER.

The principal obstacle experienced is that the ASPEN fuel cell flow model is specified as cocurrent both within the cell and between cells. Counter-current flow between stacks "split stack" is successfully simulated by specifying the process flow sequence and processing the fuel cell model block twice. The ASPEN model is not able to simulate counter-current flow within a stack. This limitation does not significantly affect the comparison.

The baseline system adjusted with fuel cell performance specifications provided by M-C POWER is compared using a full ASPEN simulation and a spreadsheet model. Performance results are virtually identical. ASPEN can perform more sophisticated equations and is easier to modify the system design. The spreadsheet has the advantage that simple modifications can be performed on the Personal Computer and, therefore, the simulation is available to most users.

Significant sharing and comparison of system and fuel cell performance data has resulted from this CRADA. DOE/METC has enhanced its knowledge and understanding of the carbonate fuel cell

and fuel cell systems. The updated ASPEN models reinforce M-C POWER projections for the material-energy balances around the fuel cell system verifying M-C POWER results. This also provides independent methods to verify the results obtained for the fuel cell system model.

The promise of high efficiencies and low emissions at competitive cost is expected to provide the driving force for continued investigation into the carbonate fuel-cell system. Intermediate-sized fuel cell power plants operating at moderate pressure are best served by expanding the exhaust before discharge to the atmosphere. It is believed that expander/alternator bottoming cycles sized at 7-12 MW are feasible. The intermediate-sized 25 MW fuel cell power plant can, therefore, offer utilities and industrial power generators an efficient plant at a relatively small size.