MOLTEN CARBONATE FUEL CELL PRODUCT DESIGN IMPROVEMENT

TECHNICAL PROGRESS REPORT FOR PERIOD
DECEMBER 21, 1999 TO DECEMBER 20, 2000

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ACKNOWLEDGEMENT

The activities reported here were sponsored by DOE/NETL and DOD/DARPA, and cost-shared by the FuelCell Energy, Inc. (formerly Energy Research Corporation) team. The key team members are: FuelCell Energy's Technology Group and Operations Group, Fluor-Daniel, Jacobs Applied Technology, and Direct Fuel Cell Group (DFCG). Numerous employees of FuelCell Energy and these organizations have contributed to this project. The role of each organization, and its principal project leaders are: **FuelCell Energy Technology Group** – R&D arm coordinating the effort under all program areas (H. Maru); **FuelCell Energy Operations Group,** Danbury, CT – for product definition oversight, overall plant construction management and customer service (C. Bentley); **FuelCell Energy Fuel Cell Group,** Torrington, CT – responsible for manufacturing process development and stack module fabrication (C. Bentley); **Fluor Daniel, Inc. (FDI),** Irvine, CA – assisting FCE Fuel Cell Group in power plant design (C. Newlander); **Jacobs Applied Technology (JAT),** Orangeburg, SC – consulting in assembly and packaging of fuel cell stack and balance-of-plant modules (H. Rast).

FuelCell Energy, Inc., the overall project coordinator provided the lead role in the execution of program tasks. The program activities are organized under seven tasks. The task leaders are A. Leo (Tasks 1 through 3 and Task 5), L. Christner (Task 4), G. Carlson (Task 6), and M. Farooque (Task 7). Numerous FuelCell Energy engineers have contributed to this report.

Interactions and guidance of Technical Representatives Richard Dennis of DOE/NETL and R. Rosenfeld of DOD/DARPA are acknowledged.

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EXECUTIVE SUMMARY

Under the cooperative agreement DE-FC21-95MC31184 with DOE/NETL, FuelCell Energy, Inc. formerly Energy Research Corporation, has been developing its direct Carbonate FuelCell (DFC®) technology for stationary power plants. The objective of the program is to develop and demonstrate a cost-effective, market-responsive DFC power plant design(s) and make it ready for commercial entry. Significant progress has been achieved during the reporting period, as highlighted below.

- Cell and stack designs were refined to enhance endurance capability and reduce material costs. The direct internal reforming catalyst life is projected to increase to >3 times over the baseline catalyst. Significant cost reduction was achieved for key stack non-repeat components.

- The 200 kW system demonstration with the product building Stack FA-100-1 was voluntarily terminated after seventeen months of grid-connected operation (~12,000h including six thermal cycles) to finalize the MW-class power plant design, next step in our path to commercialization. The total electricity generated exceeded 1,900,000 kWh. The stack performance stability observed over the entire operation met the market entry goal.

- Operation of the 30kW stack on simulated digester gas confirmed no rating and efficiency penalties associated with the use of this low-Btu renewable fuel compared to the baseline natural gas fuel.

- Manufacturing process development and capacity expansion was continued at the Torrington, CT facility. An in-house electrolyte production system was installed to lower electrolyte cost by a factor >5 and attain >>50 MW/yr capacity. An automatic electrolyte loading (into cell packages) system was also installed to improve part-to-part reproducibility and achieve 50 MW/yr capacity.

- The MW-class stack module design was improved to make it accessible to all U.S. locations and simplify field connection.

- FuelCell Energy DFC® electric/cogen products have been defined.

- Proof-of-concept submegawatt plants (250 kW in Danbury, CT and 250 kW in Bielefeld, Germany) have been operated. The bielefeld unit has achieved 47% (LHV) electricity conversion efficiency and is in operation since November 1999. Field trials of the prototype 250 kW units are expected to commence in 2001.

- FCE signed two distributorship agreements with PPL Energy Plus and Enron North America, and has been in discussion with several other potential alliances.

INTRODUCTION

The carbonate fuel cell promises highly efficient, cost-effective and environmentally superior power generation from pipeline natural gas, coal gas, biogas, and other gaseous and liquid fuels. FuelCell Energy, Inc. has been engaged in the development of this unique technology, focusing on the development of the Direct Fuel Cell (DFC®). The DFC® design incorporates the unique internal reforming feature which allows utilization of a hydrocarbon fuel directly in the fuel cell without requiring any external reforming reactor and associated heat exchange equipment. This approach upgrades waste heat to chemical energy and thereby contributes to a higher overall conversion efficiency of fuel energy to electricity with low levels of environmental emissions. Among the internal reforming options, FuelCell Energy has selected the Indirect Internal Reforming (IIR) – Direct Internal Reforming (DIR) combination as its baseline design. The IIR-DIR combination allows reforming control (and thus cooling) over the entire cell area. This results in uniform cell temperature. In the IIR-DIR stack, a reforming unit (RU) is placed in between a group of fuel cells. The hydrocarbon fuel is first fed into the RU where it is reformed partially to hydrogen and carbon monoxide fuel using heat produced by the fuel cell electrochemical reactions. The reformed gases are then fed to the DIR chamber, where the residual fuel is reformed simultaneously with the electrochemical fuel cell reactions.

FuelCell Energy plans to offer commercial DFC power plants in various sizes, focusing on the subMW as well as the MW-scale units. The plan is to offer standardized, packaged DFC power plants operating on natural gas or other hydrocarbon-containing fuels for commercial sale. The power plant design will include a diesel fuel processing option to allow dual fuel applications. These power plants, which can be shop-fabricated and sited near the user, are ideally suited for distributed power generation, industrial cogeneration, marine applications and uninterrupted power for military bases.

FuelCell Energy operated a 1.8 MW plant at a utility site in 1996-97, the largest fuel cell power plant ever operated in North America. This proof-of-concept power plant demonstrated high efficiency, low emissions, reactive power control, and unattended operation capabilities. Drawing on the manufacture, field test, and post-test experience of the full-size power plant; FuelCell Energy launched the Product Design Improvement (PDI) program sponsored by government and the private-sector cost-share. The PDI efforts are focused on technology and system optimization for cost reduction, commercial design development, and prototype system field trials. The program was initiated in December 1994. Year 2000 program accomplishments are discussed in this report.

OBJECTIVES AND APPROACH

The FuelCell Energy, Inc. PDI program is designed to advance the carbonate fuel cell technology from the current full-size field test to the commercial design. The specific objectives selected to attain the overall program goal are:

- Define power plant requirements and specifications,
- Establish the design for a multi-fuel, low-cost, modular, market-responsive power plant,
- Resolve power plant manufacturing issues and define the design for the commercial-scale manufacturing facility,
- Define the stack and balance-of-plant (BOP) equipment packaging arrangement, and module designs,
- Acquire capability to support developmental testing of stacks and critical BOP equipment to prepare for commercial design, and
- Resolve stack and BOP equipment technology issues, and design, build and field test a modular prototype power plant to demonstrate readiness for commercial entry.

PROJECT STATUS

FuelCell Energy, Inc. is currently in the fifth budget period of the multiyear program for development and demonstration of a MW-class power plant supported by DOE/NETL with additional funding from DOD/DARPA and the FuelCell Energy team. Figure 1 shows key program elements (shaded) and their interrelationships. The product definition and specifications have been derived with input from potential users including the Direct Fuel Cell Group (DFCG). The baseline power plant final design has been completed. Detailed power plant system and packaging designs are being developed using stack and BOP development results. A prototype modular power plant field trial, representative of the commercial design, is planned. In parallel, stack and balance of plant equipment development efforts are being carried out for achieving commercial market entry cost and performance goals. Based on the experience and data generated in the current program, FuelCell Energy is in the process of acquiring manufacturing capability for market-entry products through expansion of the existing Torrington production facility.

RESULTS/ACCOMPLISHMENTS

In the past year, the FuelCell Energy team has made steady progress in resolving technology issues, manufacturing process development, packaging design development and preparing for system design, analysis and verification. Major accomplishments in these areas are discussed below:

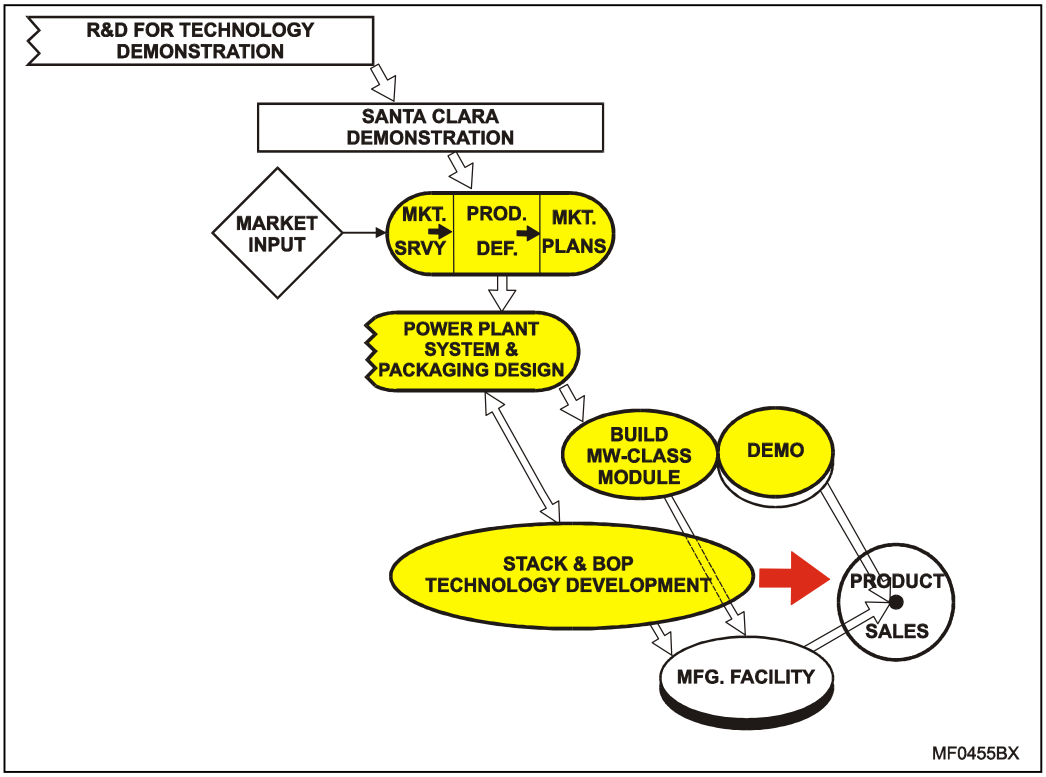

Figure 1. EFFORT AND INTERACTION OF KEY PROJECT ELEMENTS:
The Program Will Result in the Market Entry Commercial Product Design

Technology Improvement

FuelCell Energy made significant advances in the area of cell technology improvement/refinement. The activities were focused on endurance enhancement, performance enhancement and material cost reduction.

For endurance capability enhancement, advanced DIR catalysts (DIR-3 and 4) providing desired high Ni dispersion and metal surface area were evaluated. Out-of-cell (OCT) accelerated tests and single cell tests showed significantly improved activity and stability. The DIR-3 catalyst is expected to increase life by >3 times over the baseline catalyst. The DIR-4 catalyst currently under evaluation may provide further life enhancement. Advances in catalyst extrusion process for easy manufacturing and loading of the advanced catalysts included development of high density catalyst extrusion with controlled pore size distribution, and inorganic binder formulation yielding the desired extrusion as well as catalyst characteristics. The DIR-3 catalyst is currently being evaluated in 10-cell Stack FA-5-7 and is planned to be used in next full-height Stack FA-100-2 and upcoming 250 kW field trial stacks.

Material selection to meet product stability goal was completed and implemented in stack tests. The alternate bipolar plate wet seal material showed an excellent corrosion resistance in 10,000h out-of-cell test and has been implemented in Stack FA-5-7. The high corrosion resistance bellow and manifold materials have been verified in full-height Stack FA-100-1 (11,800h test). To reduce the cell shrinkage, development of the advanced doped cathode was pursued. The doped cathode after 1500h of testing showed heavy faceted grain structure which may establish mechanical interlock to improve creep resistance. The out-of-cell creep test showed little cathode creep using doped electrolyte. In-cell evaluation of this material is in progress.

The performance enhancement activities included advanced cathode development. The creep strength of the advanced cathode was found acceptable. Single cell evaluation showed excellent cell performance (Figure 2). The cathode is expected to double the projected cell life by eliminating electrolyte consumption by the current collector and increasing the cathode electrolyte storage capacity. Efforts are underway to resolve technical issues associated with implementation of this unique cathode in stacks.

Material cost reduction activities covered both the cell hardware and the stack non-repeat hardware. A low cost bipolar plate material (~ five times less expensive than the baseline design) is currently being evaluated in Stack FA-5-7. An alternate cost-effective bipolar plate wet seal material eliminating the processing need for corrosion protection in the baseline design has been successfully corrosion tested for 10,000h and is being evaluated in Stack FA-5-7. Cost of manifold gasket assembly has been reduced by more than 50%. Significant cost reduction has been achieved for all key components in the stack non-repeat hardware (Figure 3). Material surface finish of the alternate manifold dielectrics has been enhanced 3-fold for improved resistance to electrolyte wetting. The new stack compression system featuring spring packs and innovative load transfer mechanism has been designed to provide higher initial load and then a gradual decrease for reduced cell creep. All design improvements are planned to be verified in the next product building block Stack FA-100-2 prior to implementation in 4-stack MW-class module M-10 and subsequent market entry products. It is believed that the improved non-repeat component designs developed will meet the commercial entry cost goals.

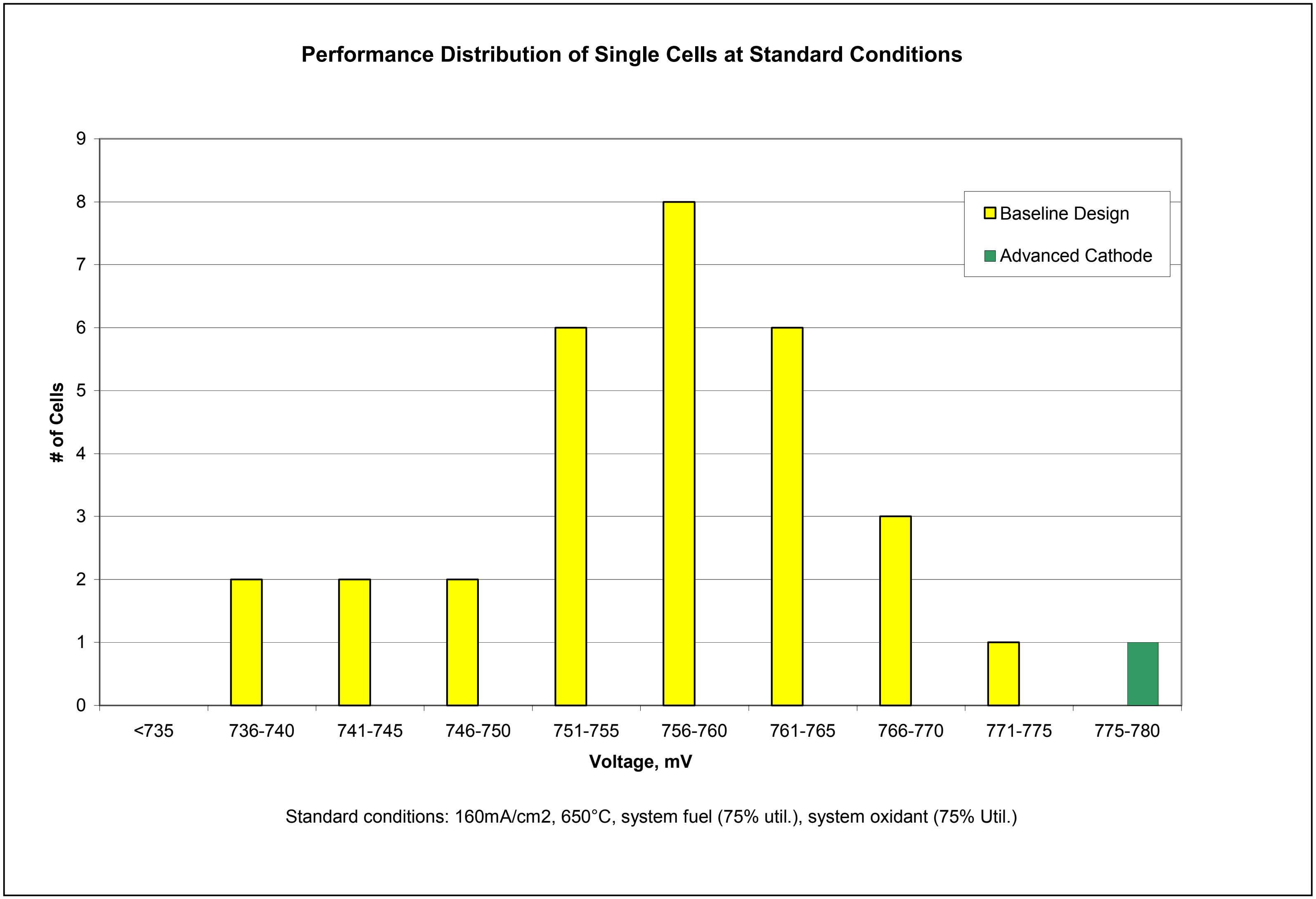

Figure 2. PERFORMANCE ENHANCEMENT OFFERED BY ADVANCED CATHODE:
Record Performance Achieved with the Long-Life Advanced Cell Design

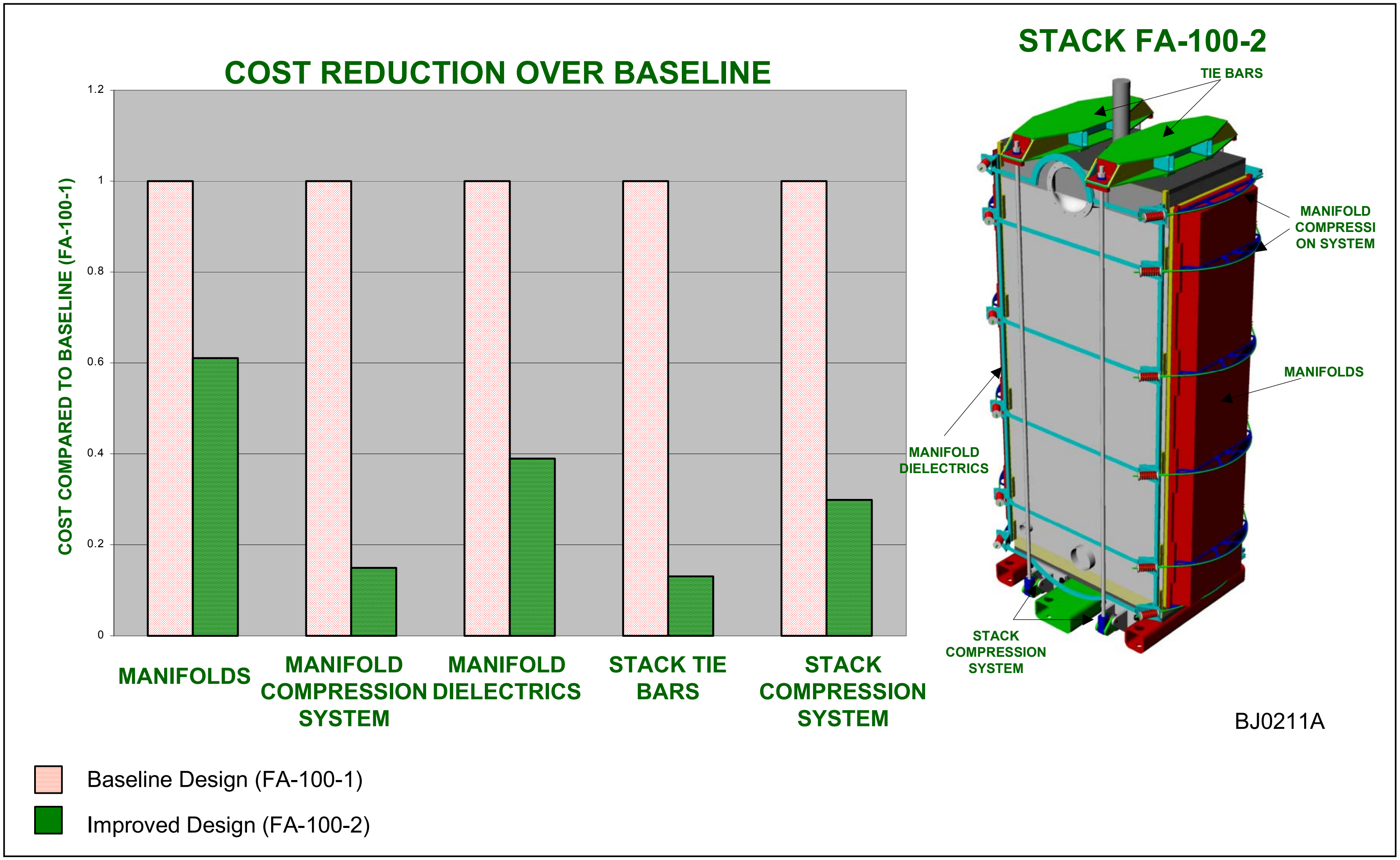

Figure 3. STACK NON-REPEAT HARDWARE COST REDUCTION:
Significant Cost Reduction Achieved for all Key Components

The key technology verification milestones reached in stack testing area were the completion of the system demonstration with the product building block Stack FA-100-1 and the long-term endurance run of the 8 kW subscale Stack FA-5-6. The technology development effort has been focusing on defining and verifying the basic building block stack design. A prototype Stack FA-100-1 (340 cells, 9000 cm^2 nominal) was built and power plant operations demonstrated for seventeen months at company's Danbury site (a photograph shown in Figure 4). The power plant was grid-connected and provided electricity to the company building. The highlights of the test are listed in Table 1. A peak power level of 263kW was demonstrated setting a world record. An excellent cell-to-cell voltage uniformity ($\pm$1.5%) was observed. The plant emission levels for SO_x and NO_x were found to be better than the U.S. Clean Air Standard. The AC power quality exceeded IEEE 519 standard. The present inverter configuration, based on local utility requirements, trips the plant for power glitches. The 250 kW plant demonstrated that the DFC® can remain online during utility power glitches of up to 2 sec. Most of the power plant operation was at 200 kW power level and included unattended automatic operation (see Figure 5). This unit was intentionally run to accumulate operational experience under various steady state and transient conditions.

Figure 4. PRODUCT BUILDING BLOCK STACK DEMONSTRATION:
MW-Class Product Stack Design is Founded on This Test

Table 1. STACK FA-100-1 TEST HIGHLIGHTS:
Produced >1,900 MWh During 17 Months of Operation

- Demonstration started February 22, 1999 and terminated on June 30, 2000
- Stack power up to 263 kW demonstrated
- Generated >1,905,000 kWh of power
- Powered Danbury facility
- >11,800h of hot operation
- Voltage uniformity ±1.5%
- Emissions <0.1 ppm SO_x; 0.05 ppm NO_x (better than clean air standard)
- DC-AC conversion efficiency 93% (2% improvement expected with PCU refinement); AC power quality exceeds IEEE 519 standard
- Demonstrated utility grid interconnection with limits specified by local utility
- Verified unattended automatic operation
- Conducted special tests
    - Six (one stressed) thermal cycles
    - Trips from various operating modes (normal and emergency)
    - Load following (achieved idle to half load operation in 3s)

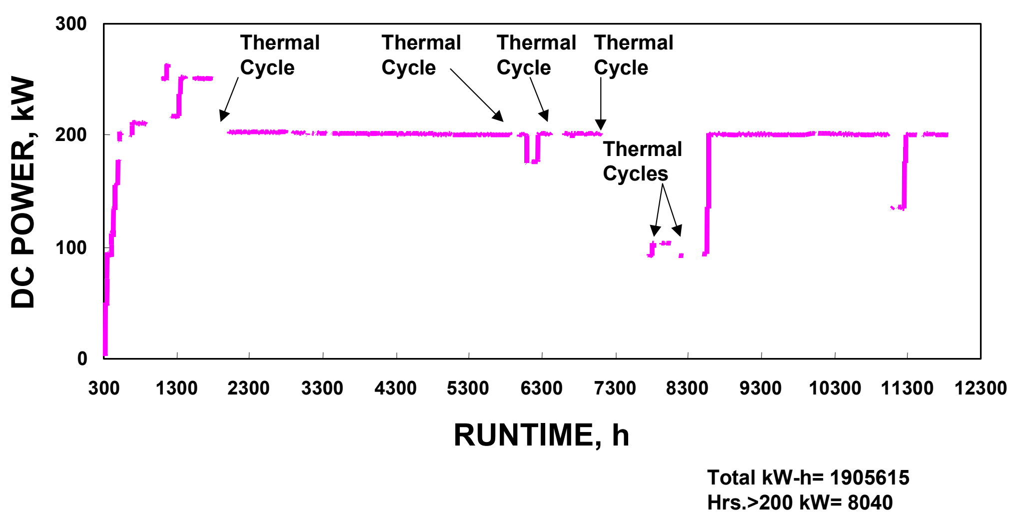

Figure 5. STACK FA-100-1 OPERATION:
11,800h of Operation Including Six Thermal Cycles

Quick load response tests were performed demonstrating idle to half load operation in 3s. A total of six thermal cycles (including one stressed cycle that simulated emergency power and/or fuel outage situations) were completed. The plant operating experience provided valuable input for BOP component design. The demonstration was concluded after ~12,000h to finalize the design for MW-class power plant, next step in our path to commercialization. The total electricity generated exceeded 1,900,000 kWh.

FuelCell Energy also operated a subscale, 8 kW DFC® Stack FA-5-6 for two years. This unit has logged 17,500h on multiple types of fuels, and has been subjected to numerous start-stop tests, further verifying the longevity and fuel versatility of the DFC® technology. Subscale stack tests to verify the design improvements also included Stack FA-20-4R (30 cells, 9000 cm^2 nominal) featuring improved anode corrugation for better flow uniformity which was tested for 3800h. Stable operation at 80% fuel utilization with improved cell-to-cell performance uniformity and reduced in-cell temperature gradient were demonstrated. This test also demonstrated robustness of DFC® design for fast load ramping (as may be required for load-following applications) by repeated load cycling with constant fuel flow between 74 to 85% fuel utilization. The Stack FA-20-4R was also tested on typical natural gas as well as digester gas system conditions. The test results (Figure 6) showed no efficiency and/or output derating for the DFC® for this renewable fuel application.

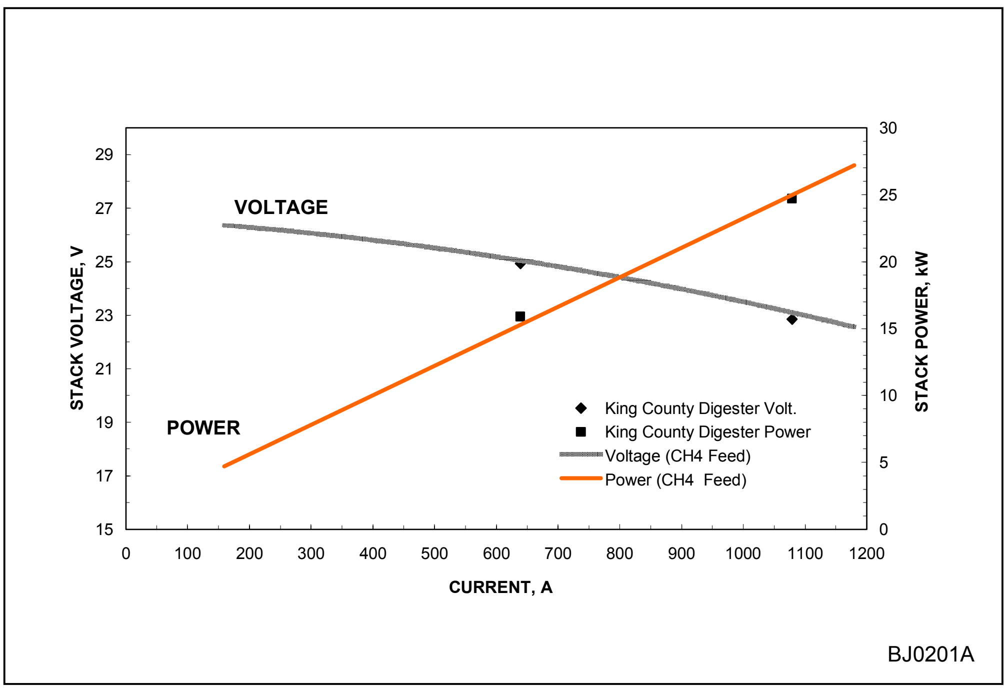

Figure 6. 30-CELL DFC STACK PERFORMANCE WITH THE MEDIUM BTU DIGESTER GAS:
No Performance Penalty Observed with the Medium Btu King County Digester Gas Compared to CH_4

All stack active components and external hardware from long-term endurance stack operation were thoroughly analyzed to determine their durability. The stack active components include Ni alloy anode, NiO cathode, electrolyte matrix and metallic bipolar plate hardware. Microscopic examination of the anode revealed very little change of the anode morphology, projecting to >>40,000h life. The NiO cathode has been reported to slowly dissolve into the carbonate electrolyte and precipitate as metallic Ni in the matrix. Metallographic cross-sectional analyses of matrix samples at various locations showed that the metallic Ni deposits were all located near the anode side. No continuous nickel chains that can cause electrical short were observed. The amount of Ni deposits in the matrix at various locations was also measured and found to be low. These results indicate that FuelCell Energy's current cell design and operating conditions pose no concerns for the projected 5-yr life.

The electrolyte matrix utilized $LiAlO_2$ as the support material. A significant phase change during operation could cause particle coarsening, pore size increase and electrolyte loss. X-ray diffraction phase analysis showed the matrix support material is essentially α-phase. Negligible phase change of the $LiAlO_2$ (from initial α-phase to γ-phase) occurred after 17,500h testing (Figure 7). SEM analysis also revealed little change in particle size. Therefore, the current matrix support material is expected to have sufficient stability for 40,000h use. The post-test analysis of cell hardware showed durability acceptable for 40,000h use. The corrosion observations of the current collectors and bipolar plate are in line with prediction (Figure 8).

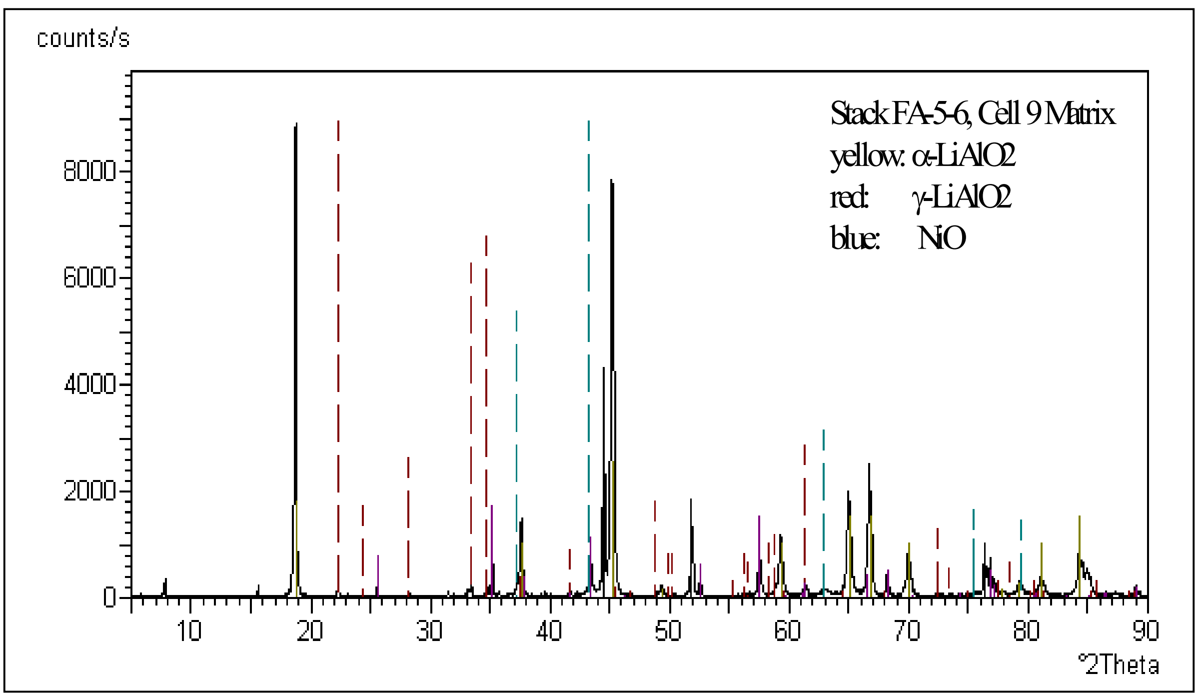

Figure 7. NEGLIGIBLE PHASE TRANSFORMATION OF THE MATRIX SUPPORT MATERIAL (α-10) AFTER 17,500h STACK USE:
Negligible Transformation from α to γ Phase was Detected;
No Concern for Matrix Material Life

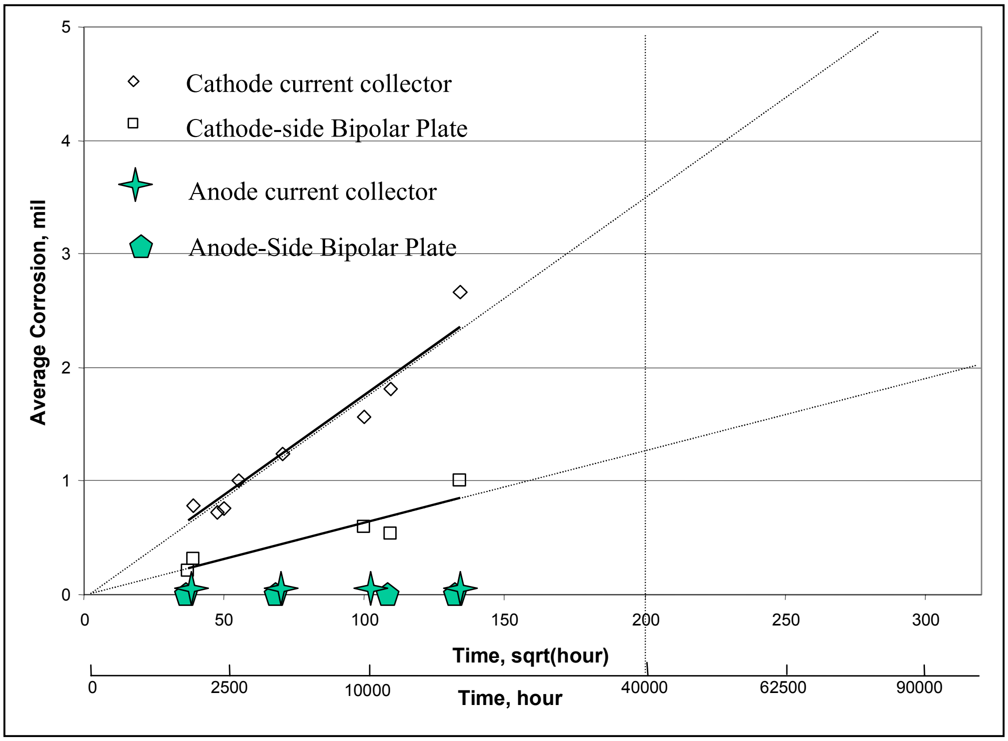

Figure 8. BIPOLAR PLATE AND CATHODE CURRENT COLLECTOR CORROSION: Cell Materials Life Goal of 40,000 is Projected in Stack Tests

The corrosion of stack external hardware (manifold, end plate, pipe bellows, dielectrics) was also thoroughly examined. Because of proper material selections, these components are all projected to have adequate corrosion resistance for 40,000h use. The ceramic dielectric material remained intact. The debris from the manifolds was found to be insignificant, owing to the selection of appropriate corrosion-resistant high-temperature stainless steel. Advanced materials selected for the thin bellows were verified to be adequate for 40,000h use. In summary, the post-test analyses of the long-term operated stacks verified the adequacy of the selected materials for commercial entry use. The information provides a valuable input for commercial DFC power plant material specifications.

Following the 250 kW system demonstration using Stack FA-100-1, post-test inspection of the balance-of-plant (BOP) equipment was completed. This facility is being upgraded to provide fuel cell/turbine hybrid system capability. The new system will integrate fuel cell and gas turbine for higher electrical efficiency. Based on observations from the existing “humihex”, the design for the new larger capacity humihex incorporated nozzles for more uniform water spray and the tube expansion joints for thermal expansion capability. Three new heat exchangers for turbine integration and the microturbine have been ordered. The piping and structural steel support installations for turbine integration have also been initiated.

Other BOP developments included evaluation of an advanced prereformer catalyst requiring no external H_2 supply, design of the gas clean-up system for MW-class products based on 250kW system operation, and development of power conditioning system vendors.

Manufacturing Process Development

FuelCell Energy, Inc. manufactures fuel cells in Torrington, Connecticut, where considerable resources have been devoted since 1991 to develop the manufacturing processes to enable the company to satisfy production requirements in a cost-effective manner. The processes have been developed to manufacture the critical active cell components that repeat hundreds of times in the building block (~360-cell full size) fuel cell stack. The FuelCell Energy products are modular and maintain a high level of component commonality to avail cost advantage of mass production. As illustrated in Figure 9, stacks used in all products are built with identical cell packages. These stacks can be cost-effectively combined to produce the megawatt-class products. The highly evolved processes, and the standardized component design are expected to result in very competitive capital costs. DFC® components are manufactured from relatively inexpensive raw materials (nickel, stainless steel, carbonates, ceramic powders, nickel catalyst, etc.) which are found abundantly throughout the world. The accomplishments in the manufacturing cost reduction area included:

1) manufacturing of full-size bipolar plate eliminating the separate processing need for corrosion protection (Figure 10) which eliminated a vendor processing step,
2) installation of low cost in-house electrolyte production system reducing electrolyte cost by a factor >5,
3) the improved anode slurry production process and
4) the demonstrated capability to produce a single layer cell matrix.

FuelCell Energy also demonstrated fabrication of the bipolar plates in-house utilizing robotic welding system. Manufacturing processes for the commercial entry product stacks have been finalized. The quality control accomplishments included the installation of an automatic cell matrix thickness measurement system.

At present, the capacity of the plant is approximately 5 MW/y on a single shift basis. FuelCell Energy is increasing capacity by purchasing equipment to replace or supplement certain elements of the manufacturing process that currently restrict the overall output of the facility. The immediate goal is to raise the output capability to 50 MW per year in 2001. Detailed specifications for the major rate controlling equipment have been defined. The specifications for a facility capable of 50 MW/y production rate have been generated. Efforts have been launched to acquire the necessary equipment and facilities.

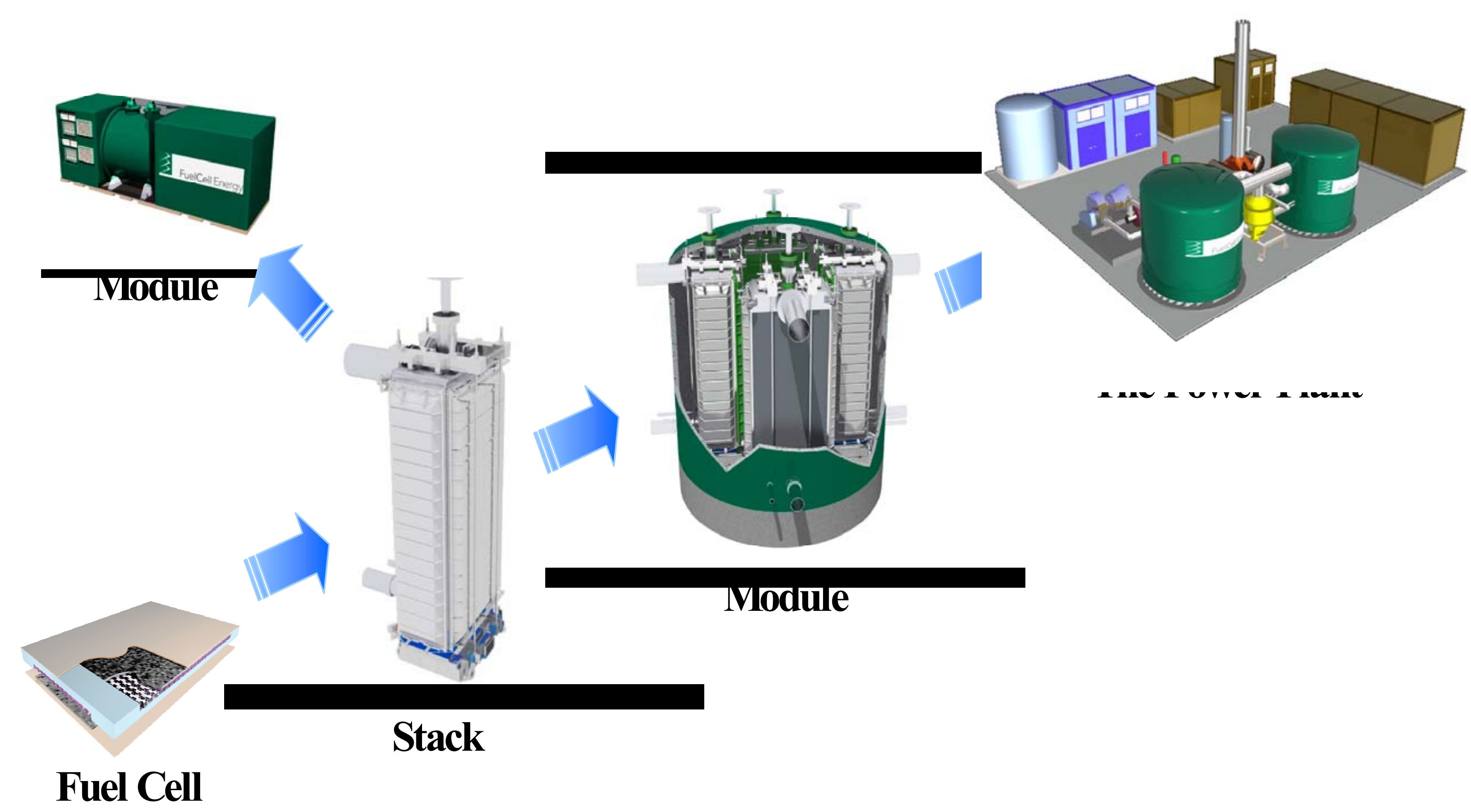

Figure 9. MODULARITY OF FUELCELL ENERGY PRODUCTS:
Standardized Products Will Use Identical Fuel Cell Packages

Figure 10. COST-EFFECTIVE BIPOLAR PLATE MANUFACTURING DEVELOPED:
Eliminates Separate Processing for Corrosion Protection

The final stack assembly process is time and labor intensive and does not lend itself to automation or continuous production processes, at least initially. Following stack assembly, each unit will be conditioned and tested to prepare the unit for operation prior to shipping. FuelCell Energy anticipates performing the stack component manufacturing and completing stack assembly in Torrington, and conditioning at satellite plants located close to the customer clusters. Balance of plant will be purchased, packaged and delivered to power plant sites by strategic suppliers currently under development. The first set of conditioning facilities are being setup at Danbury, CT.

The site civil work for the stack module conditioning and performance checkout for MW-class and submegawatt facilities at Danbury, CT is underway. The vendor quotes for major equipment have been solicited. The planning for reuse of some major equipment from Santa Clara Demonstration Project (SCDP) plant is in progress. New schedule for BOP completion is late summer 2001. The facility will then be used for the first full-size 4-stack module M10 test. The test will verify the readiness of the stack module for field demonstration.

Module Assembly and Packaging

The MW-class module design was updated to provide unlimited access to potential power plant sites in the US by truck and to reduce the field installation costs. The diameter of the original cylindrical shell was decreased by 2 in (5 cm). The shell was cut in half and 12 in. (30 cm) panels were added. The new configuration provided room to assemble the internal flow distribution system, feeding the four internal fuel cell stacks (Figure 11). The module shipping height was reduced from 12 ft. 11 in. (394 cm) to 12 ft (366 cm) by redesigning the lower support system and the head. The field erection cost was reduced by decreasing the field pipe/nozzle connections from 13 (in the baseline design) to 5. The enclosure is designed per NFPA 69 to contain the worst-case deflagration from mixing and combustion of fuel and oxidant gases. To FuelCell Energy's knowledge, this is the only fuel cell that is designed to this safety standard.

The module enclosure internal flow distribution system 1/10 scale model-flow test has been completed. The results showed that the current design meets the set criteria of less than ±0.5% flow variation between stacks. The design has been approved. The fabrication drawings are being prepared. The first field trial MW-class module will be ready in 2001 for test evaluation.

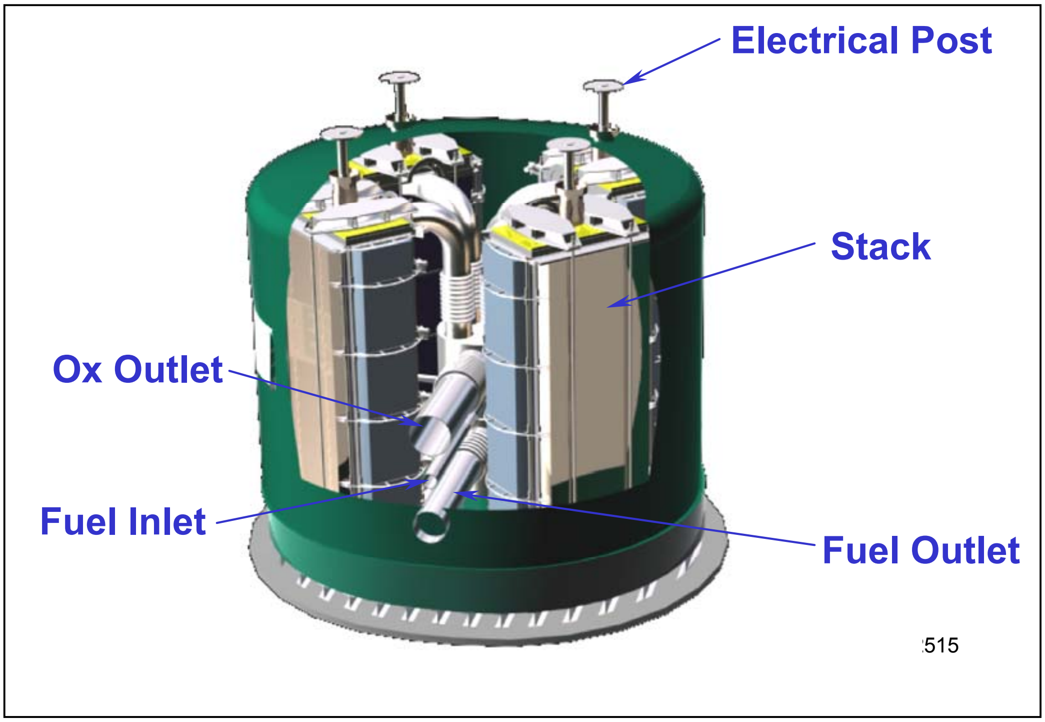

Figure 11. MW-CLASS 4-STACK MODULE:
Accessible to All U.S. Locations by Truck and Requires Only
Five Pipe Connections in the Field

System Design, Analysis and Verification

FuelCell Energy, Inc. is developing three modular products: two MW-class products rated at 1.5 MW (single module, 4 stacks) and 3 MW (two modules, 8 stacks), and a sub MW-class product with a rating of 300 kW (single stack). Based on the latest cell performance projections, the product specifications were updated for the three products selected. In addition, the system performance was analyzed for combined power and heat (Cogen and Trigen) applications. Total system efficiency of 92-94% (HHV) were projected. The final design of the 3 MW product including detailed equipment specifications, packaging drawings, detailed capital and operating cost estimates has been completed. The detailed design of the 3 MW plant will evolve with component vendor feedback in the construction phase of the prototype. FCE's technology partner MTU has developed the submegawatt power plant design. FuelCell Energy has upgraded this design for conformance with US codes and standard for field trial to start in Year 2001.

The development of fuel cell codes and standards has also continued. NFPA 853 code for safe installation of fuel cell power plants has been ratified by full NFPA and is now official. The first draft of IEEE P1547 standard for distributed resources interconnected into electric power systems was completed. Updating of the ANSI Z21 standard for construction and quality assurance of fuel cell power plants smaller than 1 MW has been initiated.

Toward development of strategic supplier relationships; discussions with potential candidate organizations for electrical/mechanical equipment supply and packaging, and for distribution and servicing arrangements have been initiated. FuelCell Energy selected PPL (Pennsylvania Power and Light) EnergyPlus, LLC, an energy marketing and services arm of PPL Corp., as the first North American distributor of FuelCell Energy's Direct Fuel Cell (DFC®) products. PPL is a leading supplier of competitively priced electricity and energy services in the mid-Atlantic region. PPL will provide comprehensive power plant operations and maintenance (O&M) management services for the field trial power plants procured and/or sold by PPL. The agreement signed by FuelCell Energy with PPL EnergyPlus is a major milestone in establishing strategic supplier/distributor alliance relationships. In addition, FuelCell Energy entered into an alliance with Enron North America, a wholly owned subsidiary of Enron Corp. FuelCell Energy and Enron will work together to develop and market FuelCell Energy's DFC® products, focusing on state-sponsored renewable programs and energy conservation opportunities. The alliance is expected to bring reliable, cost effective and clean energy to the market place.

Future Activities

Technology activities will focus on: 1) verification of cell and product building block stack designs in next full-height Stack FA-100-2, 2) continuation of Torrington, CT based manufacturing facility expansion to 50 MW/y capacity, 3) continuation of sub-MW product field trials, and 4) parallel efforts on performance, cost, and endurance improvements.

Performance demonstration of the DFC™ power plant(s) is considered critical to successful commercialization. FuelCell Energy has selected both submegawatt and megawatt class projects as its primary focus for the field trials. The strategy involves multiple submegawatt product field trials in Europe as well as US to demonstrate performance, durability, and cross-continent code compliance.

The first field trial in Europe at Bielefeld, Germany is already in progress. The cogen plant is providing electricity to the local municipal electricity grid and steam to the University campus achieving electrical efficiency of 47% (LHV). Seven additional submegawatt projects have been negotiated (Table 2). Demonstration of the MW-class system on digester gas has been planned under an EPA and King County, Washington sponsored program. Demonstration of the MW-class system on coal-gas has also been planned under another DOE-sponsored clean coal project.

Table 2. FUELCELL ENERGY FIELD TRIALS PLANNED OR IN PROGRESS:

250kW	Bielefeld (Germany; in operation) Mercedes Benz (US) LADWP (US) – 3 units Marubeni (Japan) Rhone Klinikum (MTU)
1MW (Digester Gas)	King County (EPA/King County)
2MW (Coal-gas)	DOE Clean Coal/Global Energy