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ERC Commercialization Activities

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CONTRACT INFORMATION

Cooperative Agreement	DE-FC21-95MC31184
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Other Funding Sources	ERC, EPRI, NRECA
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Period of Performance	December 1994 to July 1999

BACKGROUND INFORMATION

The ERC family of companies is anticipating market entry of their first commercial product, a 2.8-MW power plant, in the second quarter of 1999. The present Cooperative Agreement provides for:

- Commercialization planning and organizational development
- Completion of the pre-commercial DFC technology development
- Systems and plant design
- Manufacturing processes' scale-up to full-sized stack components and assemblies
- Upgrades to ERC's test facility for full-sized stack testing
- Sub-scale testing of a DFC Stack and BOP fueled with landfill gas

This paper discusses the first item, that of preparing for commercialization.

ERC's formal commercialization program

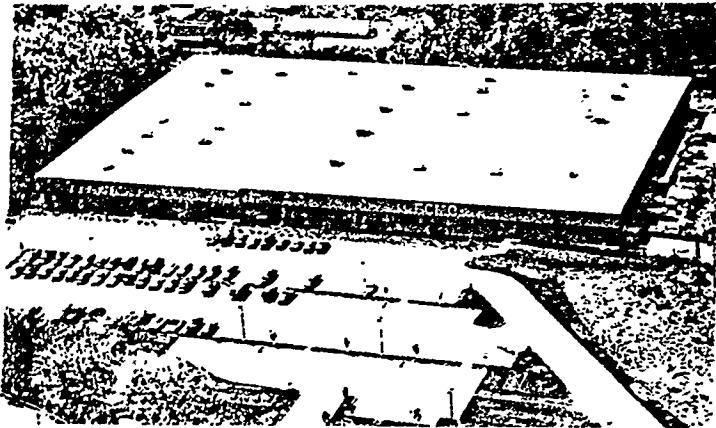
began in 1990 with the selection of the 2-MW Direct Fuel Cell power plant by the American Public Power Association (APPA) for promotion to the over 2000 municipal utilities comprising APPA's segment of the utility sector. Since that beginning, the APPA core group expanded to become the Fuel Cell Commercialization Group (FCCG) which includes representation from all markets - utilities and other power generation equipment buyers.

Through a strong combination of Federal and privately sponsored R&D accompanied by demonstration programs, ERC's family of companies is aggressively making the transition from the laboratory to a manufacturing capability and market entry. Once underway, the planned line of products will reap significant rewards for U.S. enterprise in terms of jobs, revitalization of some primary manufacturing industries (steel, electronics, electrical and control industries, and other equipment suppliers), and other related service-based support organizations. This should also provide a contribution to a more favorable

trade balance from the anticipated foreign demand for these systems. Of most importance, however, DFC power plants meet our demands for efficiently produced electricity respectful of our environment in a surging economy.

To serve commercial customers, ERC established two subsidiaries, the Fuel Cell Manufacturing Corporation (FCMC) and the Fuel Cell Engineering Corporation (FCE). Over \$12 million of private sector financing has been raised to launch these two entities through an initial capital formation effort in support of ERC's fuel cell activities. Most of these funds have been applied to build and equip an operational manufacturing plant that is supplying DFC stacks and modules for the coming demonstration projects. The FCMC manufacturing facility is shown in *Figure 1*. Both of the new firms are

Figure 1. FCMC's Manufacturing Facility



establishing their respective commercial functions through contracts with the DOE and the Santa Clara Demonstration Project (SCDP). As part of the current program, a verification of the commercial power plant design is planned.

Since being selected in February 1990 by the Fuel Cell Commercialization Group (FCCG) as the company and technology of choice, FCE/ERC

and the FCCG have entered numerous cooperative efforts, all derived from the spirit of the collaborative initiative. ERC/FCE have shared technical data, test experiences, and system design requirements with the group. Each of the buyers/members has executed confidentiality agreements to allow a free transfer of material allowing for a robust interchange to hone the 2-MW power plant to a market-acceptable product.

The FCCG-FCE collaboration is precedent-setting in that a buyer's group is actively participating in the design, demonstration, and commercial introduction phases of a new technology product into a conservative, risk-averse industry. One approach to presenting the dynamics of the commercialization scheme is to describe the separate functions comprising the effort and the ways in which the parties are interacting in each to affect a positive outcome. The FCCG-ERC collaboration is now five years old. The interactive program scopes the functions of information transfer, system planning, design and engineering, early production unit model contract, and organizational cooperation at corporate executive levels. These activities are conducted through the following mechanisms:

- Committee meetings
- Board of Director meetings
- Executive Committee guidance
- Program triggers
- Program reviews

The past two years have seen this structure become increasingly vital to the technical, business, and economic directions of the commercialization effort. ERC has prepared a Commercialization Plan defining the series of technical, business, and financial paths for completion of product development, manufacturing, demonstration and production units, anticipated customers and markets, and the implementation of a corporate organization. This plan is currently being updated.

MARKET CONDITIONS

The utility business is topsy-turvy. Open transmission access, retail wheeling, and EWGs are new terms that translate to deregulation and intensified competition to serve loads. All this comes at a time when electricity demand is growing (as predicted) in response to the ongoing economic recovery. The general response by investor-owned utilities, the segment most impacted by these new situations, is no new large plant orders, further deferrals in older plant retirement, implementing reductions in staff, and cutting r&d expenditures. The net effect is that reserve margins are decreasing while most procurement actions for new generation are overseas.

As these predicted power shortages become reality, u.S. utility and industrial sector expansion could be inhibited. Large new coal- and nuclear-based power plants cannot be constructed inside of 8-10 years from project definition due to the long licensing cycles and environmental barriers. Further, the high investment costs are at risk given the litigious nature of dissident groups who have effectively paralyzed implementation of large central station projects.

Fuel cell power plants can be easily sited due to their inherent quiet, clean-operating features. Because they are modular they can rapidly be erected and placed in service. California is setting the precedent in permitting fuel cell by waiving most, if not all, of the combustion limitations applicable to conventional plant site requirements. With these barriers streamlined, new fuel cell-based capacity as well as repowering units can proceed to the construction phase more rapidly. Cost savings will accrue in the shorter overall lead-times from receipt of order to start-up. Fuel cell engineering corporation (fce) projects that our first product, a 2.8-Mw factory-built power plant, can be on-site within 12-16 months after receipt of factory orders. Energy cost savings will

accrue due to high efficiency, ease of siting, power quality, cogeneration option, and low environmental intrusion for electricity customers while providing a fuels flexible power generator to utilities. Having said all this, what has changed since the early 1990s that could impact market attractiveness, applications, and procurement of the remaining financial support to complete the development cycle?

NATIONAL POLITICS

In November 1994, the voters elected a Republican controlled Congress for the first time in modern memory. The "Contract with America" called for reductions in (energy) R&D from among the areas where the new Congress targeted dramatic spending reductions along with calls to eliminate the DOE itself. As was the case with the Reagan/Bush Administrations of the 1980s, big ticket programs and high cost demonstrations were said to be the province of the private sector and market-driven forces according to the Republican led legislature. Similarly, environmental improvements gained over the past 15-20 years through stricter emission and waste clean-up standards are being challenged by this same Congress as being too costly and therefore limiting corporate profits and trade competitiveness. Adding further to this situation, fossil energy costs remain low encouraging liberal consumption patterns by all end users.

Juxtaposing on to these movements, the government appears committed to deregulating the electric utility industry. This change may not, of itself, act against utilities accepting better generation investment, the role of transmission and distribution companies aided by the statistics describing a current overcapacity condition. Questions effecting utility investment strategies include loss of their limited monopoly status by allowing open access to all power providers, changes in depreciation allowances for assets including real property and equipment comprising

generation facilities, and retail wheeling. These are business tidal waves for the normally conservative, long protected, investor owned systems.

These current issues diminish somewhat the energy conservation-new energy technologies movement of the last decades. The attractiveness of fuel cells for their quiet, high efficiency, low polluting operation remains. However, in preparation for the increased competition among power providers portended by the national policies

mentioned, utilities are streamlining their staffs and reducing their characteristically high priority, as well as lowering their funding for R&D. This comes at a particularly crucial period for advanced fuel cell systems where market entry is anticipated by the late 1990s with full scale demonstrations remaining to qualify the commercially configured power plants. It may take a few years for the utility sector to shake out may before the industry resumes a new "business as usual" stance as these impacts become the norm.

Figure 2. Marketing, Distribution and Services Plans

- **MARKETING PLANS**
 - MAXIMIZE FCCG PARTICIPATION-CUs ORDERED WITH EPU_s
 - REGIONAL SALES REPS IN DIVERSIFIED MARKET LOCATIONS
 - UPA in 5-State territory
 - Others chosen as *quid pro quo* for support, business opportunities
 - STRATEGIC ALLIANCES FOR SITE AND SERVICES ACTIVITIES
 - FCE-Fluor Daniel
 - Timing tuned to program progress-enhances value to FCE/ERC
 - Manufacturing & Production Facilities strategies development
 - CENTRALIZED SALES-ADVERTISING MANAGEMENT PROGRAM INITIALLY;
REGIONAL/CUSTOMER SENSITIVE PLAN LATER
- **SUPPLIER & PRODUCT AWARENESS INITIATIVES**
 - EXHIBIT-PARTICIPATE IN TRADE MEETINGS
 - EEI/APPA/NRECA/IEEE
 - PRESENTATIONS-ON AGENDAS AT TARGET MARKET MEETINGS
 - NCPA/ESEERCO/EPRI
- **DISTRIBUTION PLAN**
 - CONCENTRATE IN TARGETED EARLY MARKETS
 - California, Northeast and North Central States
 - FORM JOINT VENTURES OR FRANCHISES
 - Use FCCG Buyers, other "local knowledge" firms
- **SERVICE PLAN**
 - DEVELOP MODULE, SPARE PARTS SUPPLY DEPOTS
 - LINK O&M CAPABILITIES WITH DISTRIBUTION FUNCTIONS

MARKETS AND APPLICATIONS

Despite the preceding scenario, in our opinion, the longer range outlook continues to appear most promising for advanced fuel cells and especially the carbonate-based Direct Fuel Cell (DFC) in megawatt class systems. This optimism stems from the nation's sustained strong economic performance, the national will to actually reduce the deficit, and the requirement that older generation systems must be replaced and new capacity must be added for an increasingly electricity dependent U.S. and world.

In 1983-84, ERC selected a two-megawatt DFC commercial power plant for our initial commercial product. This size was felt to respond to the widest breadth of potential with a broad diversity of applications. Many of these are shown in *Figure 2*. The application shown are particularly suited for the 2-3 megawatt class system now in primary design. The member-buyers of the Fuel Cell Commercialization Group (FCCG) are working with FCE to finalize a standard contract for their unit purchase, to assist with the plant's performance envelope, and to provide for O&M. FCCG members represent over 20% of the nation's generation capacity and a prime source for early and sustaining unit sales if their initial experience with the first units bears out the potentials of this product and technology.

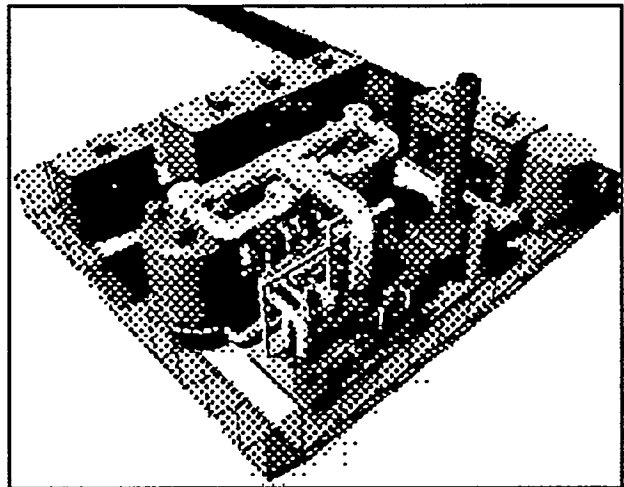
The 2.8-MW Power Plant

First conceived in 1984, our analysis of the unit's conceptual design indicated power could be produced at an efficiency approaching 60% when fueled by natural gas. The original design concept maximized fuel utilization, recovery and recycle of unspent hydrogen and product water. Called the "Integrated System" it is believed to be an ultimate carbonate fuel cell system capable of the highest conversion efficiency known by any generator requiring only a natural gas (methane) source for operation (no

facility water is needed). This was the commercial baseline until 1991 when a "simplified system" design was conceived. In this configuration, only the most basic power plant functions were retained to truly simplify the system and lower the unit costs. With Fluor-Daniel's assistance, we determined that the unit cost is about \$300/kW less while still providing relatively high efficiency at 50%, and preserving the environmentally attractive features of fuel cell plants. The commercial entry unit chosen is the "Simplified System" although there is a high interest to also be able to offer the other system design somewhat later.

The unit, shown in *Figure 3*, requires less than 4500 ft² for its installed location and because of its low noise and low pollution operation, can be easily sited in urban or suburban settings, either indoors or adjacent to existing structures. Because of the internal reforming feature, the hydrogen inventory is consumed instantaneously thereby imposing no safety constraints on the unit's installed location.

Figure 3. FCE's 2.8-MW Power Plant



Over the next 12-18 months, FCE expects to have over 30 executed contracts for the first production series, called Early Production Units (EPUs).