

COMMERCIALIZATION OF PEM FUEL CELL TECHNOLOGY

Presented by Jay Neutzler: **Director of Engineering**: *Energy Partners at the DOE/EPRI/GRI Fuel Cell Technology Review Conference, August 3-5, 1999 Chicago*

ABSTRACT *by Morna McGann, Marketing Director*

This presentation focused on the strategies and issues that Energy Partners is working on in the advancement and commercialization of PEM fuel cell technology. The following points were discussed in the presentation. The transportation and utility market was defined as two key markets to commercialization. Energy Partners outlined their program for designing low cost high quality products and components for manufacturing and assembly, and stated their current technology development status in PEM fuel cell technology. The Energy Partners prototypes, system development, system design/analysis, and technology systems development was outlined highlighting the current work that was done in the automotive area (**FutureCar project**) and the stationary power market (**Energy Partners Personal Power Systems**) for distributed generation. The company projected their future plans and costs for development and manufacturing in the transportation and residential commercial stationary power markets and expansion of their production facilities and product production.

ENERGY PARTNERS, L.C.

THE PEM FUEL CELL COMPANY

Introduction

ENERGY PARTNERS, L.C., a West Palm Beach, Florida based limited liability company, is committed to the research and product development of PEM fuel cell technology. Since 1990 Energy Partners has been at the forefront of PEM fuel cell technology development. They have developed fuel cells for a range of stationary and automotive applications. Operating out of an 18,000 square foot facility with 38 employees with engineering, technical, and business backgrounds, Energy Partners has full prototype production, design and advanced testing capabilities. We are leaders in development and demonstration of PEM fuels cells and systems and have demonstrated and produced more PEM fuel cell concepts and stacks than any one in the U.S. industry.

Energy Partners current technology includes advanced hydrogen PEM fuel cell stacks with a maximum power rating of 20kW, prototypes of various sized reformat capable fuel cells, with planned near term power ratings of 65kW and demonstrations of direct hydrogen vehicles. We are currently working on Alpha prototypes of integrated fuel processor/fuel cell systems for the automotive and stationary power industries.

Experienced in research and development, Energy Partners is transitioning into a product-based company with near term focusing on the primary power, back-up power and microcogeneration markets.

Energy Partners has attained an unmatched reputation for product performance and reliability. Their distinguished and growing list of clients and sponsors includes *Deere & Company, Ford Motor Company, NUI Corporation, the U.S. Department of Energy, the Australian Department of Defense and the National Aeronautics and Space Administration.*

PRODUCT DEVELOPMENTS

Listed below is a synopsis of Energy Partners sales, research and development projects from 1995 through the present:

SALES PROJECTS

DATE	PRODUCT	CLIENT
1994-1995	PEM 7.5kW H2/O2 Vehicle <i>Genesis People Mover</i>	Western Golf Car
1995-1995	PEM 2.5kW H2/Air Fuel Cell Stack & Single Cell Test Fixture	Instituto Nacional deTécnica Aeroespacial, Madrid, Spain
1995-1995	PEM 5 kW H2/O2 Fuel Cell System	U. S. DOE Engineering Center, Rockwell International, CA
1995-1996	PEM 5 kW H2/O2 Fuel Cell Test System NASA , Lyndon B. Johnson Space Center	Cooperative R&D Agreement
1996-1996	PEM 10kW H2/Air Fuel Cell Stack	U.S. DOE/Ford
1996-1996	3 PEM 10 kW H2/Air Fuel Cell Stacks	Fraunhofer Institute for Solar Energy Systems, Germany
1996-1997	2 PEM 10kW H2/Air Fuel Cell Stacks for “Gator” Utility Vehicles	Deere & Company <i>Demonstrated at Palm Springs Regional Airport</i>
1997-present	2 PEM 20kW Fuel Cell Stack	U.S.DOE/Virginia Tech & TexasTech Universities <i>FutureCar Project</i>
1998-present	PEM 3.5 kW H2/Air Fuel Cell Stack	Northwest Power
1999-present	PEM 3kW H2/Air Fuel Cell Stack	Hamburg Gas Consult Hamburg, Germany

RESEARCH & DEVELOPMENT PROJECTS

DATE	PROJECT TYPE	CONTRACT TITLE	AGENCY/RESEARCH FACILITY
1995-1995	Research Study; SBIR Phase I	Electrostatic Deposition of Catalyst on Polymer Membrane for Fuel Cell Application	National Science Foundation, Arlington, VA
1995-1995	Engineering Study	Fuel Cell Assessment, U.S. Hybrid Propulsion System Dev.	U.S. DOE/Ford Motor Company
1995-1996	R&D	Direct Hydrogen PEM Fuel Cell for Automotive Applications	U.S. DOE/Ford Motor Company
1996-1998	Design Study	Advanced PEM Fuel Cell for Transportation Applications/Design & Delivery of Prototypes	U.S.DOE
1997-present	Research Study	Development of Advanced Low Cost PEM Fuel Cell Stack & System Designs for Operation on Reformate & Use in Vehicle Power Systems	U.S. DOE
1997-1998	Design Study	Phase I Industrial Fuel Cell Vehicle	Southeast Technology Center
1998-present	Product Research & Development Use Use Nupower™	10kW PEM Natural Gas Fuel Cell System Home Stationary Power	A Joint development project between Energy Partners & NUI Corporation
1998-present	Phase II Delivery	Fuel Cell Prototype Vehicles Industrial Fuel Cell (2) Vehicles (2) PEM 10kW Fuel Cell Stacks <i>Project is slated to be further evaluated for commercialization phase in the near future.</i>	Southeast Technology Center
1998-present	Engineering Study	Contact Resistance & Testing of Gas Diffusion Layer Prototypes	Spectracorp/U.S. DOE
1998-present	Design Study	Integrated Renewable Hydrogen	U.S. DOE/Office of Energy Efficiency &Utility System (IRHUS) Renewable Energy Hydrogen Program

Energy Partners Product Performance



NG2000
 20 kW_{nom}
 60 Vdc_{nom}

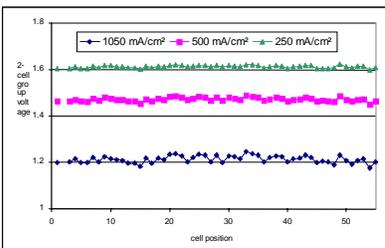
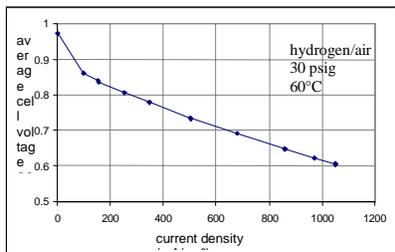


Figure 1: Energy Partners' NG2000-20 PEM Fuel Cell Stack & Performance

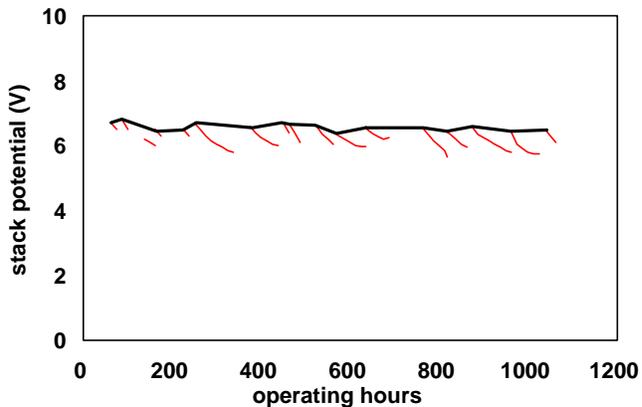


Figure 2: NG2000 1,000 hr Continuous Operating Test

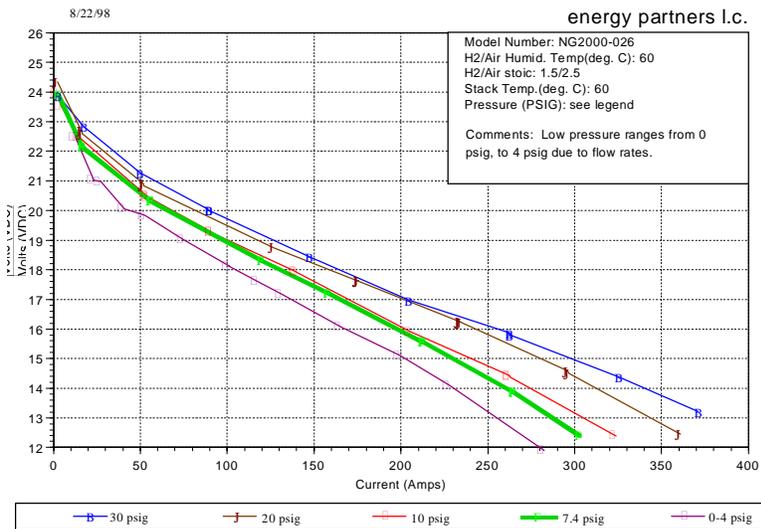


Figure 3: Partners NG2000-5 Performance Operating Under Different Pressures

Energy Partners, L.C. Owners

Energy Partners, Inc.

Energy Partners, Inc. is owned primarily by Mr. and Mrs. John H. Perry, Jr. with small, minority ownership by certain key employees. Mr. John H. Perry, Jr., a native of Seattle, Washington, was born on January 2, 1917. He graduated from Hotchkiss in 1935, Yale in 1939, and attended the Harvard School of Business Administration. During World War II he served as a pilot in both the Anti-Submarine Service and the Air Transport Command.

Following the war, Mr. Perry was Chairman, President and principal shareholder of Perry Publications, Inc. which operated 28 newspapers, as well as magazine publishing and printing operations. He is widely recognized for his pioneering introduction of computers for automated newspaper production in the composing room. This was a forerunner to today's techniques in high-speed newspaper production.

John H. Perry, Jr. was an early predictor of the ending of the "fossil fuel age" and the beginning of the "hydrogen age." Over 25 years ago, he began devoting time and significant financial resources to the development of renewable energy technologies and a global energy plan. He established research facilities in South Florida and on his private island in the Bahamas, testing photovoltaics, windmills and fuel cells. His companies built the underwater astronaut/scientist training facility off the Bahamas, known as "Hydro-Lab." The Hydro-Lab has been recognized for many underwater "firsts", including the dry transfer of men from a submarine (also Perry built). He was on President Johnson's U.S. Commission on Marine Sciences, Engineering and Resources. His efforts resulted in the first submarine powered exclusively by a fuel cell power system. His numerous companies, including Perry Oceanographics and The Perry Group, hold the patents on many of the first practical applications of fuel cell technology and were long-standing suppliers of products to branches of the U.S. military and NASA.

Mr. and Mrs. Perry founded Energy Partners, in 1990 and both serve as members of the board of Energy Partners, L.C.

NUI Corporation

NUI Corporation (NYSE: NUI), based in Bedminster, New Jersey, is a multi-state energy sales, services and distribution company. NUI has responded to a changing and increasingly competitive business environment by strengthening its core operations, while expanding its interests to broaden business opportunities.

The NUI utility divisions comprise Elizabethtown Gas Company (NJ), City Gas Company of Florida, North Carolina Gas, Valley Cities Gas (PA), Elkton Gas (MD), and Waverly Gas (NY). The NUI affiliates are NUI Energy, Inc., a natural gas and energy services retailer; NUI Energy Brokers, Inc., an energy wholesaler; NUI Environmental Group, Inc., an environmental project development operation; and Utility Business Services, Inc., a customer information systems and services subsidiary. NUI also owns a 49 percent interest in TIC Enterprises, LLC, a national sales and marketing outsourcing firm.

Key Relationships

- a) **W.L. Gore & Associates** - Gore is Energy Partners lead developer and supplier of MEA's. This relationship has existed since 1995, when Energy Partners became the first tester and user of the Gore Primea™ MEA series. We operate under several different confidentiality and purchase order style agreements.
- b) **3M Corporation** - 3M is a new entrant in the PEM field and is developing advanced MEA concepts.
- c) **Johnson Matthey Corporation** – Johnson Matthey is involved in both MEA and fuel processor development. We are currently testing prototypes of each.
- d) **Epyx Corporation** - Energy Partners is involved in testing Epyx fuel processor technology and has led the effort to integrate their first natural gas fueled unit with a fuel cell system.
- e) **Other: Vendors** - Energy Partners works with a number of vendors in the fuel cell and related fields with which it maintains standard vendor relationships.
- f) **Other: Users** - Energy Partners has developed a significant list of parties interested in the use of PEM fuel cell technology. The depth of these relationships vary from initial contact to discussions for near and long term testing/use, to actual acquisition of EP generated prototypes.

Project Management Team

Energy Partners has a skilled team of engineers, technicians and business professionals and an advanced design and testing facility. *The Senior Engineering Project Management Team* and their qualifications are listed below. They have over 50 years combined experience in various fields with specialty expertise in the following multi-discipline engineering areas: Chemical, nuclear, mechanical, electrical, and mathematical, comprising research, design, development, manufacturing, and managing.

SENIOR PROJECT MANAGEMENT TEAM

Name	Years of Experience	Degrees	Technical and Business Skills/Experience
Rhett Ross	11	M.E.M.E., Univ. of Florida, 1993. B.S. Nuclear Eng., Univ. of Florida, 1986.	<ul style="list-style-type: none"> • Vice President , Product Development for Energy Partners • As Director of Business Development, duties include profit and loss responsibility and business negotiations. • Participated on the US Congress' Office of Technology Advisory Panel for the Review of "Advanced Automotive Technology," the South Coast Air Quality management District's Fuel Cell Implementation Task force and the 1995 American Assembly Policy Session on the "Fueling the Future." • President of the US Fuel Cell Council • 6 years as qualified engineering officer aboard a nuclear submarine • Program Manager for a one-year nuclear refit. • Experience as consulting engineer in forensic engineering.
Frano Barbir	20+	Ph.D.M.E., Univ. of Miami, 1992. M.S.Chem.E., Univ. of Zagreb, Croatia, 1985.	<ul style="list-style-type: none"> • Chief Research Engineer for Energy Partners conducts and directs internally and externally funded R&D projects. • Energy systems research and development including renewable energy sources, hydrogen as an energy carrier, PEM fuel cell flow patterns and diffusion effects, and mass and heat balance. • Principal Investigator/Project Manager on Development of Advanced PEM Fuel Cell Stack for Transportation Applications with 2.5 times improvement in power density over the previous design. • Principal Investigator on Integrated Renewable Hydrogen Utility System project. • Associate Editor of the <i>International Journal of Hydrogen Energy</i>. • Has over 80 publications, including chapters in books and encyclopedia, journal articles and papers in conference proceedings.
Mario Nadal	20+	Ph.D.E.E. Univ. of Florida, 1976. M.S. Mathematics, Univ. of Puerto Rico, 1974. B.S. Mathematics, Univ. of Puerto Rico, 1972. B.S.E.E. , Univ. of Puerto Rico, 1971.	<ul style="list-style-type: none"> • Program Manager, Alpha stationary power system project. • Task Manager of SCAQMD funded award to deliver 2 fuel cell powered vehicles to Palm Springs Airport. • Responsible for fuel cell electrical and control systems design and fabrication. • Experience with advanced digital signal and image processing techniques, mathematical modeling in electro-optics, high-energy laser and laser radar.

Jay Neutzler	18	M.S.M.E. Arizona State Univ, 1995. B.S.M.E., Univ. of Kansas, 1982 MCL	<ul style="list-style-type: none"> • Dir. of Engineering, DOE PRDA II program, manage research/technical direction to produce 50 kW net automotive reformate fuel cell stack/system. Including MEA performance/characterization, composite bi-polar plate development, stack design, and systems integration. FC stack designs includes pressurized 10-65kW & 2-20kW, ambient 0.5-10kW & 0.15-1kW, and passive 5-25W. • Product development for aircraft avionics equipment. Project control, design/dev., analysis, customer interface, and FAA environmental testing/certification. Responsible for new products and for 20 product lines. Support production issues. • Environmental testing—Temperature, humidity, altitude, vibration, shock, crash safety, water tolerant, fluid susceptibility, salt spray/fog, sand & dust, fungus/bacteria, magnetic/EMI/RFI/power susceptibility, lightning strike/surge, and explosion proof. • Versed in analytical, computational, and experimental approaches. Including FEM/FEA (thermal, stress, vibration). • Manufacturing process optimization with Computer Aided Manufacturing (flexible mfg. systems) and Computer Aided Process Planning (group technology). • 2 Fuel Cell Patents, 3 Patents Pending
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