FuelCell Energy

Electrochemical Hydrogen Compression (EHC)

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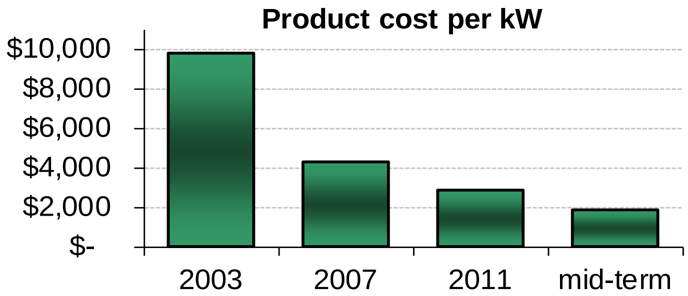
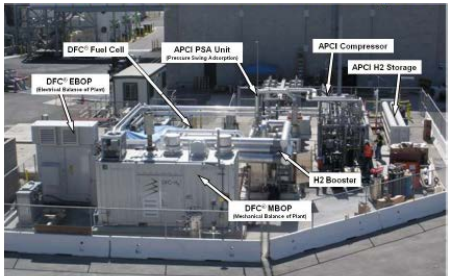
FCE Overview

- Experience with all fuel cells – MCFC, SOFC, PEM, PAFC, etc.
- Excellent progress in commercialization of MCFC technology (>300 MW installed + backlog, >50 MW per year production rate, 11 MW single site unit in Korea, >1.5 billion kWh produced)
- Unique internal reforming technology for high efficiency fuel cells





Advanced Hydrogen Co-production Technology

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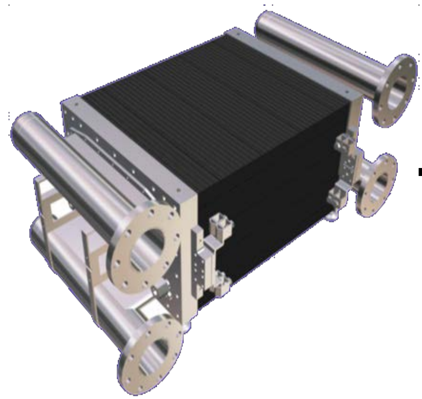
DFC® Power Plant

(Electricity + Hydrogen)



Solid State Hydrogen Separator (EHS)

Solid State Hydrogen Compressor (EHC)

H_2

Fuel Cell Cars

Materials Handling Equipment

Liquid Biofuels

Peak and Back-up Power

MO3145

1 yr Factory Test at FCE

>2.5 yr Site Demo at OCSD

(DFC-H2-PSA)

100-cell baseline stack tested

Advanced CO-tolerant stack tested for 1 year

1 year operation at 3,000 psi

Feasibility of 12,000 psi demonstrated

Strategic Alliance with Hydrogen Users

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EHC Technology Status

Parameter	Program Goals	Current Status	DOE Goals
Hydrogen Product Pressure	Up to 3,000 psi building block, 6-12 kpsi	**12,800 psi single stage** **6,000 psi 2-stage**	12,500 psi
Hydrogen Inlet Pressure	5 - 300 psi	**0 – 2,000 psi**	300 psi
Compression Ratio	Up to 300:1	**300:1**	43:1
Hydrogen Recovery Efficiency	90 - 95%	**>95%**	99.5%
Hydrogen Flux	500 -1,000 mA/cm^2	**750 mA/cm^2 for >6,000 hrs**	High
Hydrogen Capacity	2-4 lb/day at 3,000 psi	**~0.8 lb/day**	Up to 1000 kg/day
Endurance Capability	1,000 hrs at 3,000 psi	**>8,000 hrs at 3,000 psi**	>5 years
Compression Efficiency	<10 kWh/kg at 3,000 psi	**6-12 kWh/kg from <30 to 3,000 psi**	6.2 kWh/kg from 300 to 12,500 psi

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Technology Challenges

- Cell Technology: Creep of cell materials (especially electrode support) increases resistance and power requirement
- Hydrogen backdiffusion through the membrane: reduces compression efficiency
- Seal degradation (time, T, compression cycling): higher operating temperature reduces cost, but limits life
- Stack Technology: Higher current density operation is limited by stack cooling strategy; >1,000 mA/cm^2 needed to reduce capital cost
- Scale-up: cell area, stack height for 6-12 kpsi operation
- Manufacturing: tighter tolerances reduce yields and increase cost
- H_2 embrittlement and excessive yield of compression hardware

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Key R&D Activities

- Larger-area multi-cell stack technology development needed for greater capacity building block, longer-term endurance testing, innovative packaging
- Develop lower-cost protective coatings with desirable tolerances
- Develop hydrogen-resistant seal materials and designs with acceptable creep at higher operating temperatures
- Higher strength materials development needed for 6-12 kpsi operation (lower-cost support layers with higher yield strength and spring constant, engineered structure, …)
- Develop membranes with lower H_2 diffusion (new materials, barrier layers with low electrical resistance)
- Develop robust, low-cost thermal and water management systems