Direct Fuel Cell/Turbine Systems for Advanced Power Generation

Presented at :

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FuelCell Energy

INTRODUCTION

Direct FuelCell® / Turbine

- FUELCELL ENERGY, INC (FCE) IS CURRENTLY INVOLVED IN THE DEVELOPMENT OF FUEL CELL/TURBINE HYBRID POWER PLANTS UNDER A VISION 21 PROJECT SUPPORTED BY THE US DEPARTMENT OF ENERGY (DE-FC26-00NT40798)

  - Technology development is focused on the integration of FCE's Direct FuelCell® (DFC®) with Gas Turbines in an ultra high efficiency power plant configuration.

VISION 21 PROJECT

OBJECTIVES

- **DESIGN OF 40 MW HYBRID POWER PLANT**
- **SYSTEM EFFICIENCY > 75%**
- **COST COMPETITIVE WITH OTHER ENERGY SYSTEMS**
- **ULTRA LOW EMISSIONS: <.01 lbs/MMBTU of SO_x and NO_x**

OVERVIEW

OF

ULTRA HIGH EFFICIENCY

DFC/T® TECHNOLOGY

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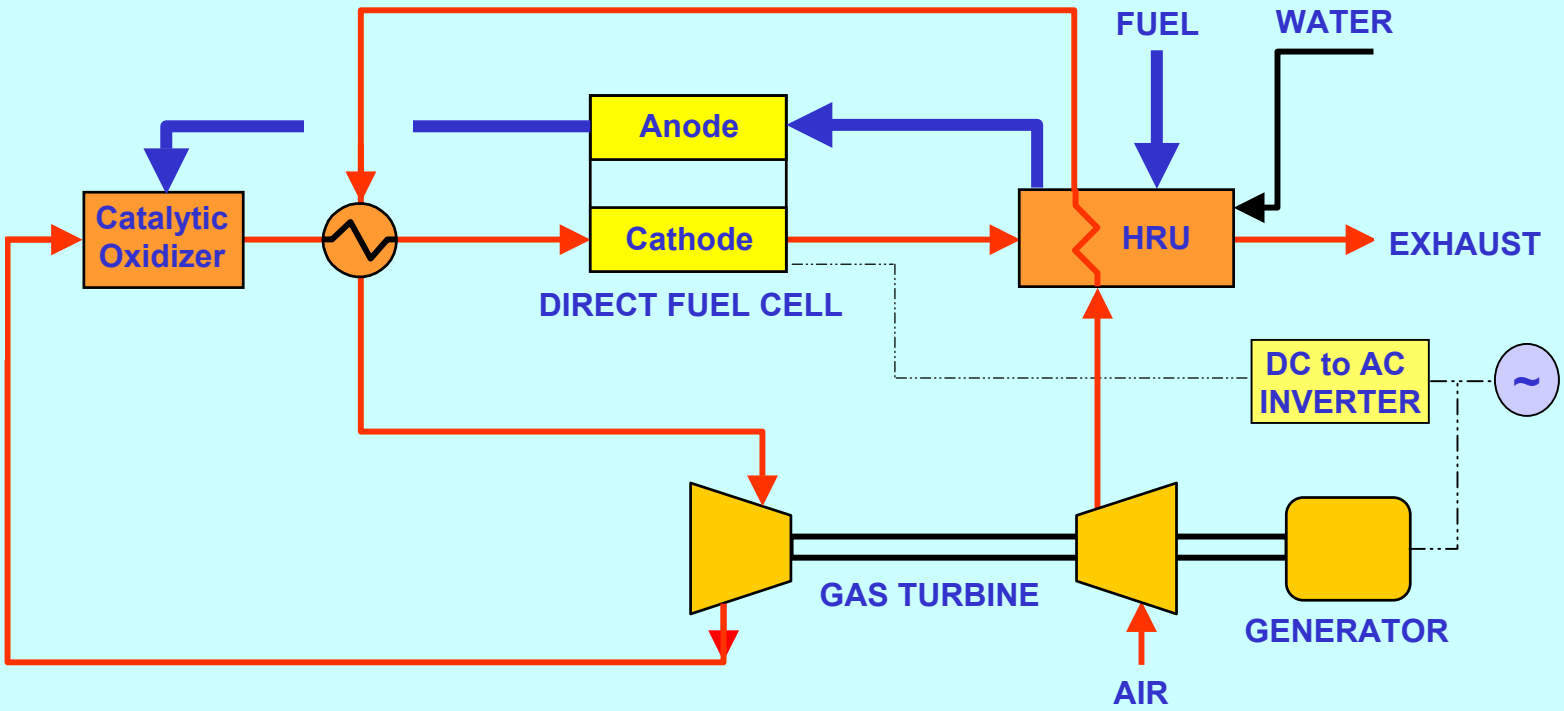
HIGH EFFICIENCY HYBRID DFC® / TURBINE POWER PLANT

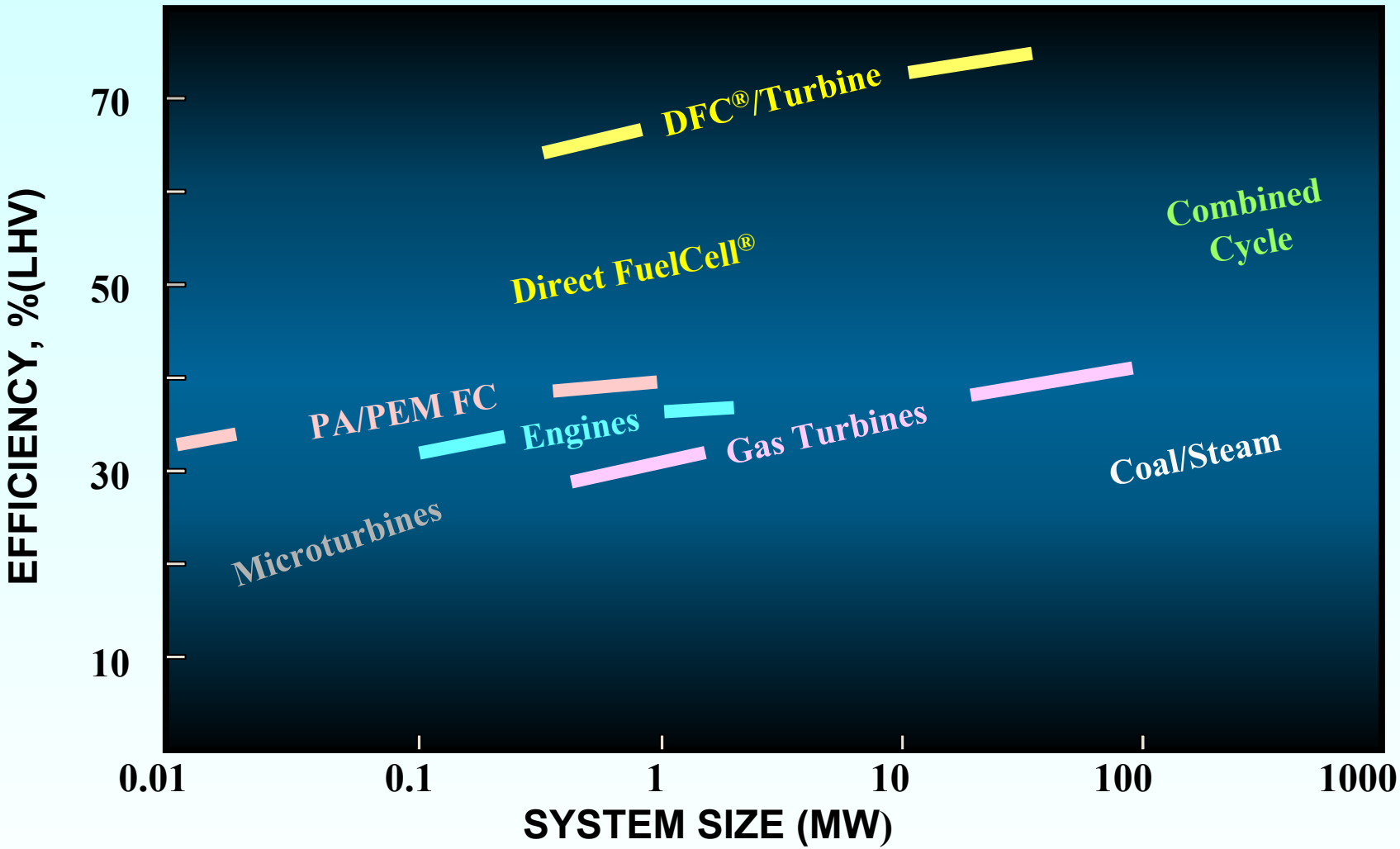


- *Low Cost of Electricity Compared to Combined Cycles*
- *Efficiencies of ~ 75% are possible*

ADVANTAGES OF DFC/T® SYSTEM

- **FUEL CELL IS PRIMARY SOURCE OF POWER GENERATION**
- **TURBINE PRESSURE RATIO INDEPENDENT OF AMBIENT PRESSURE FUEL CELL**
- **FLEXIBILITY IN OPERATION OF FUEL CELL AND TURBINE**
- **SIMPLICITY OF DFC® DESIGN AND INTERNAL REFORMING FEATURE RETAINED**
- **NO NATURAL GAS COMPRESSION REQUIRED (UNLESS A SUPPLEMENTAL DIRECT FIRING OF TURBINE IS DESIRED)**
- **PROJECTED LOW COST AND HIGH EFFICIENCY**

Comparative Efficiencies of Electric Power Plants



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MO1402C

Product Development for 10-50 MW Applications

20 MW Ultra–High Efficiency DFC® /Turbine Power Plant

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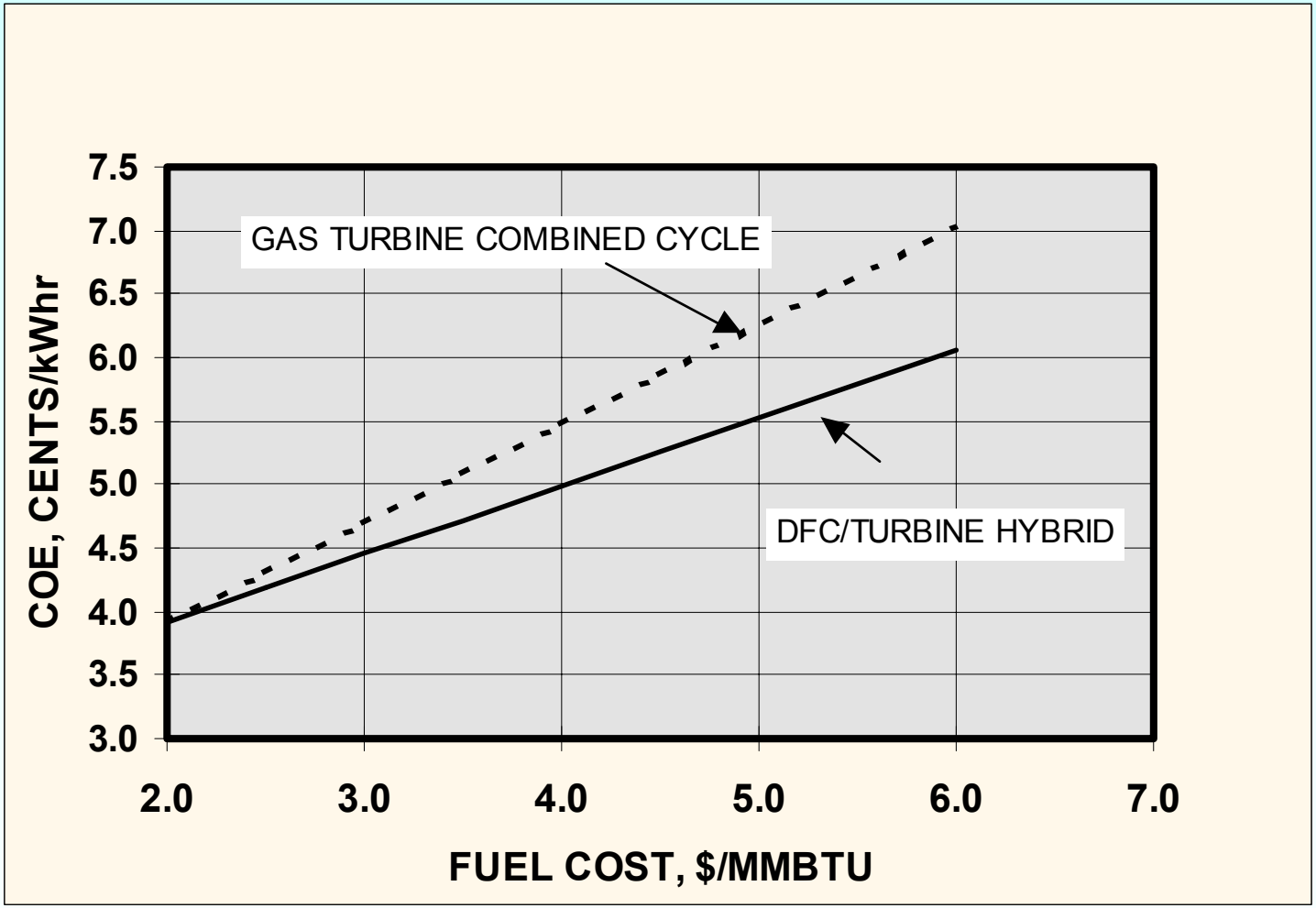
COST OF ENERGY: Comparison of GT Combined Cycle with DFC/Turbine Hybrid



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VISION 21

DFC®/TURBINE POWER PLANT

CONSTRUCTION AND OPERATION

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SUBSCALE DFC®/MICROTURBINE INTEGRATION TESTS

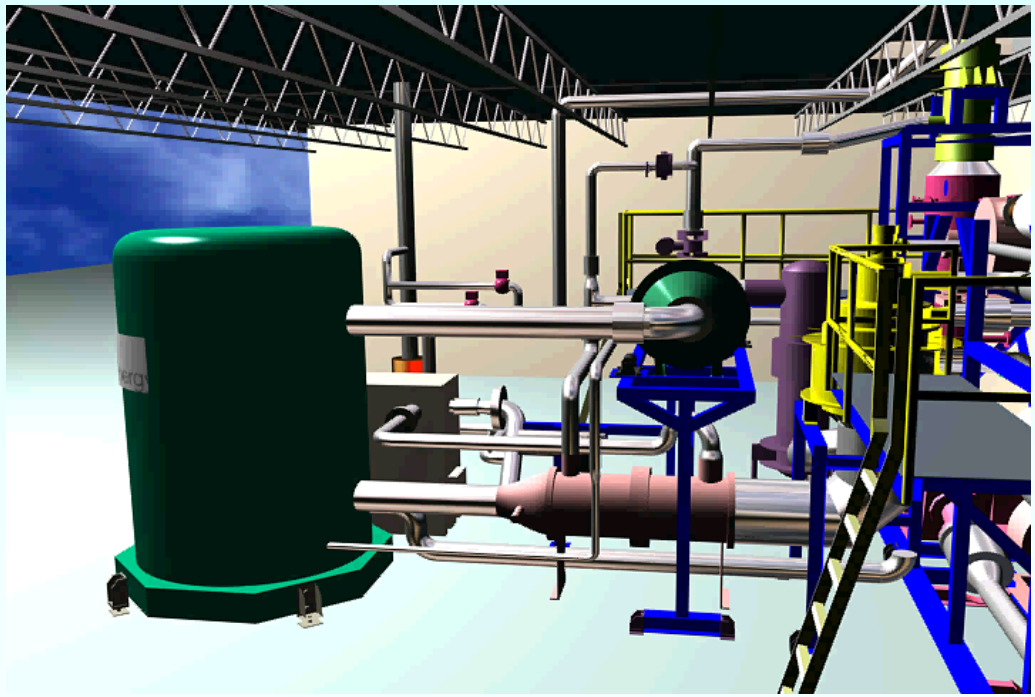
OBJECTIVES

- Proof-of-concept of DFC/T® system by integrating a 250kW DFC® stack with a microturbine in a sub-MW power plant
- Gain operational and design experience
- Develop and identify the design of critical components for 40 MW DFC/T® system

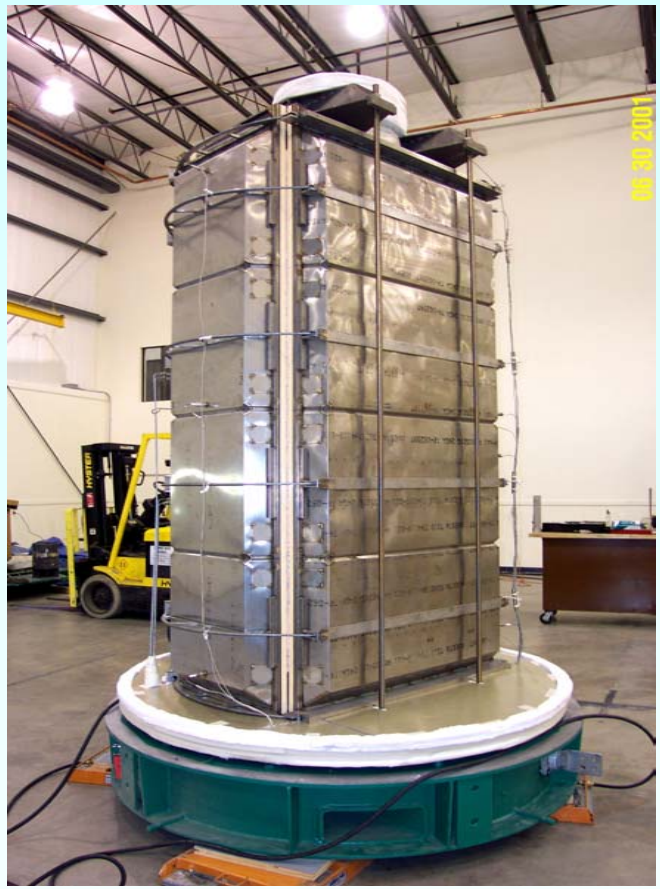
SUB-MW CLASS DFC/T® POWER PLANT OPERATING MODES

The power plant is designed to operate in dual mode

- **FUEL CELL CONDITIONING**
- **DUAL MODE OF OPERATION**
  - **FUEL CELL ONLY**
  - **INTEGRATED FUEL CELL/TURBINE**
- **RESTART / SHUTDOWN**



FULL-SIZE STACK ACCOMPLISHMENT



FA-100-2 BUILT WITH LOW COST NON-REPEAT COMPONENTS

MODIFICATIONS OF MICROTURBINE FOR DFC/T® TESTS

- MECHANICAL / DESIGN MODIFICATIONS
- MATERIALS
- CONTROL / DATA COMMUNICATION

CAPSTONE MODEL 330
(Simple Cycle)

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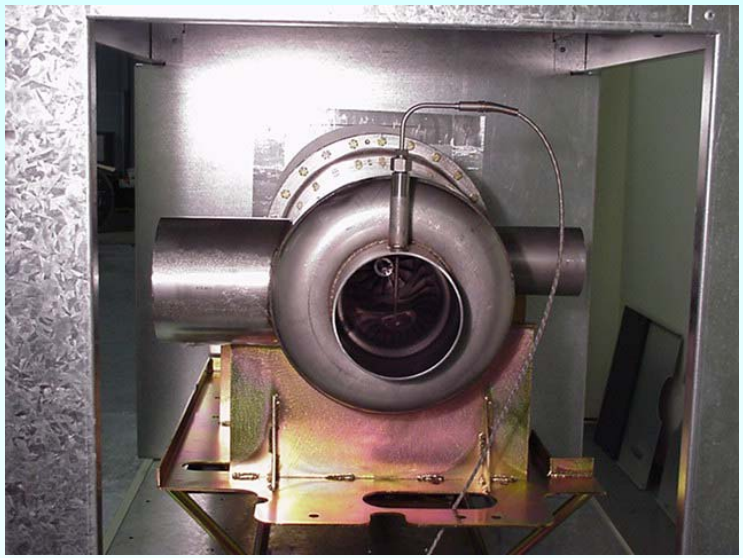
MECHANICAL / DESIGN MODIFICATIONS OF MICROTURBINE

- **IMPROVED THRUST BEARING CAPABLE OF >20 IWG**
- **INLET/OUTLET PORT CONNECTIONS TO THE BALANCE-OF-PLANT**
- **MODIFIED CASING**

CONTROL/ SOFTWARE MODIFICATIONS OF MICROTURBINE

- **COMMUNICATION OF MICROTURBINE'S CONTROLLER / DATA ACQUISITION HARDWARE TO FCE'S CONTROL SYSTEM**
- **MICROTURBINE CONTROL SOFTWARE MODIFICATIONS**
  - **Speed Control**
  - **Expander Inlet Temperature Control**
- **SURGE AND TRIP CONTROL**

MODIFIED CAPSTONE SIMPLE CYCLE MicroTurbine™



Capstone Simple Cycle Model 330 MicroTurbine™ at FCE Test Area

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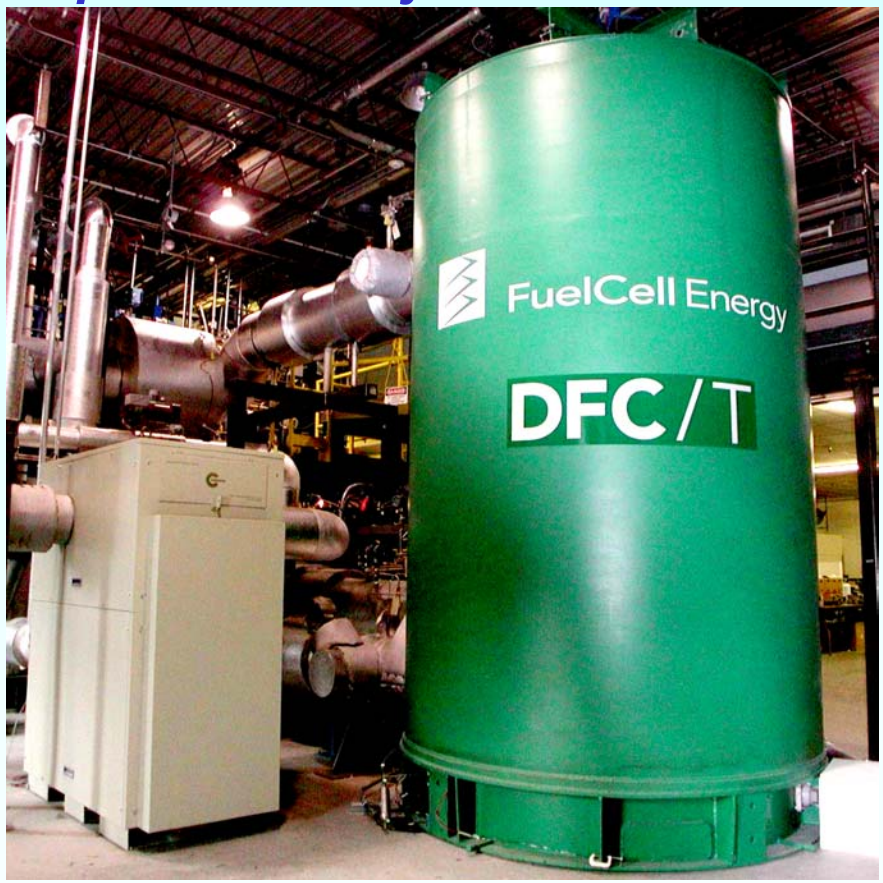
Vision 21 Project Milestone

Demonstrated operation of hybrid subMW for >4500 hours



250kW DFC® stack integrated with a Capstone 330 Microturbine

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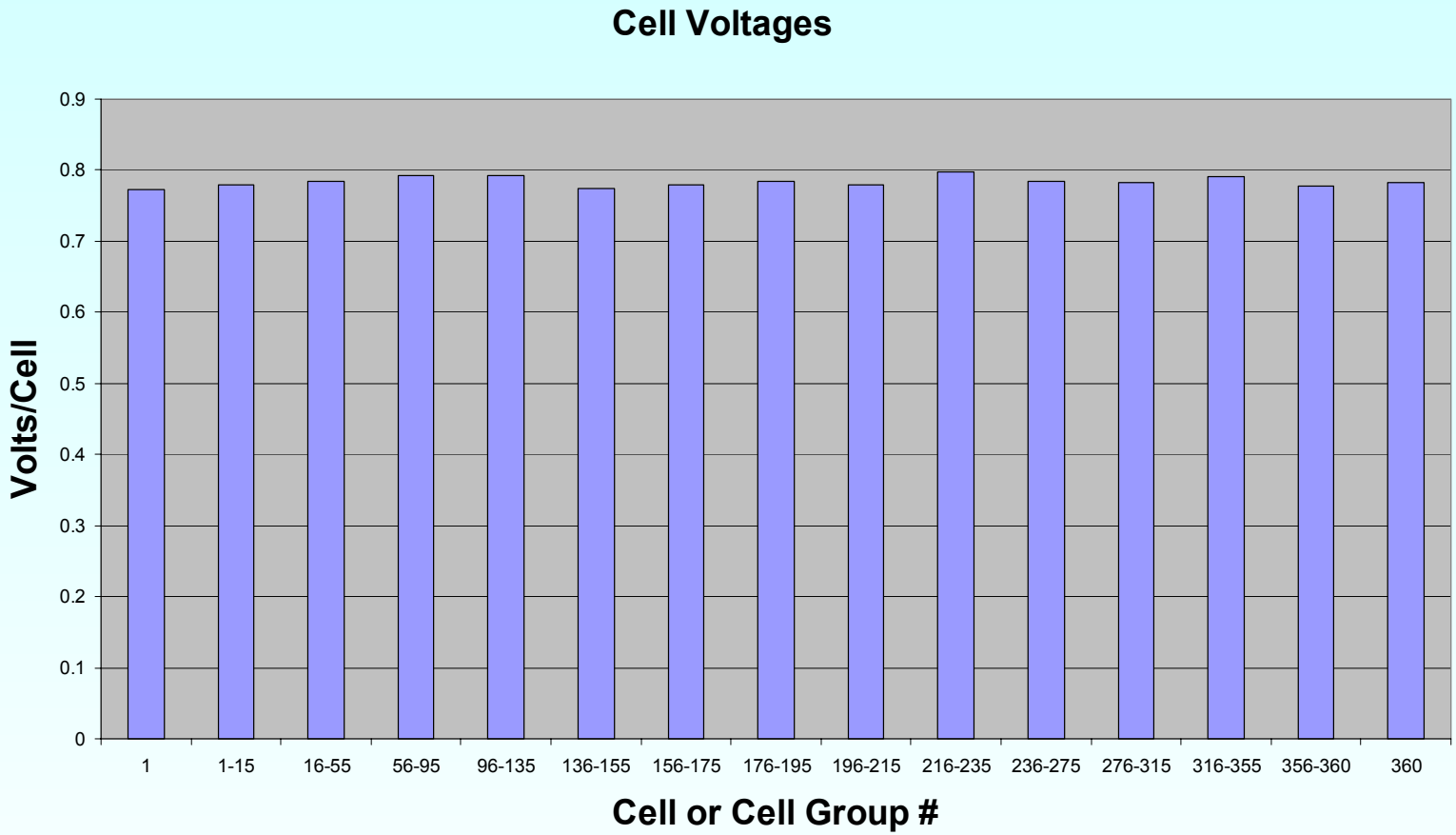
FULL-SIZE STACK OPERATION ACCOMPLISHMENT



UNIFORM PERFORMANCE ACHIEVED

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Objectives Met

- Verified DFC/T® Concept
- Modes of Operation Tested:
  - Fuel Cell Only
  - Fuel Cell with Turbine Integrated and Operated at Various Operating Conditions
- Thermal Management Confirmed
  - Fuel Cell Operating Temperature
  - MT Expander Inlet Temperature
- Trip/Emergency Scenarios Tested and Successful
- Refinement of Control Strategies thru Operational Experience
  - Validation of Control Philosophy for Commercial Production

FUTURE DEVELOPMENTS

- **Continue sub-scale DFC/T® power plant tests**
- **Complete design of the 40 MW DFC/T power plant**
- **Investigate suitable gas turbine and recuperator technologies for the 40MW plant:**
  - **Mechanical modifications (Compressor exit port and turbine Inlet port)**
  - **Range of air flows suitable for fuel Cell operation**
  - **Capability to control air flow with load**
  - **Intercooled and multistage compressors for high pressure ratio gas turbines (PR>10)**
  - **Turbine reheat section**

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