

CONTINUOUS OPERATION OF PEM REGENERATIVE FUEL CELL SYSTEM FOR ENERGY STORAGE

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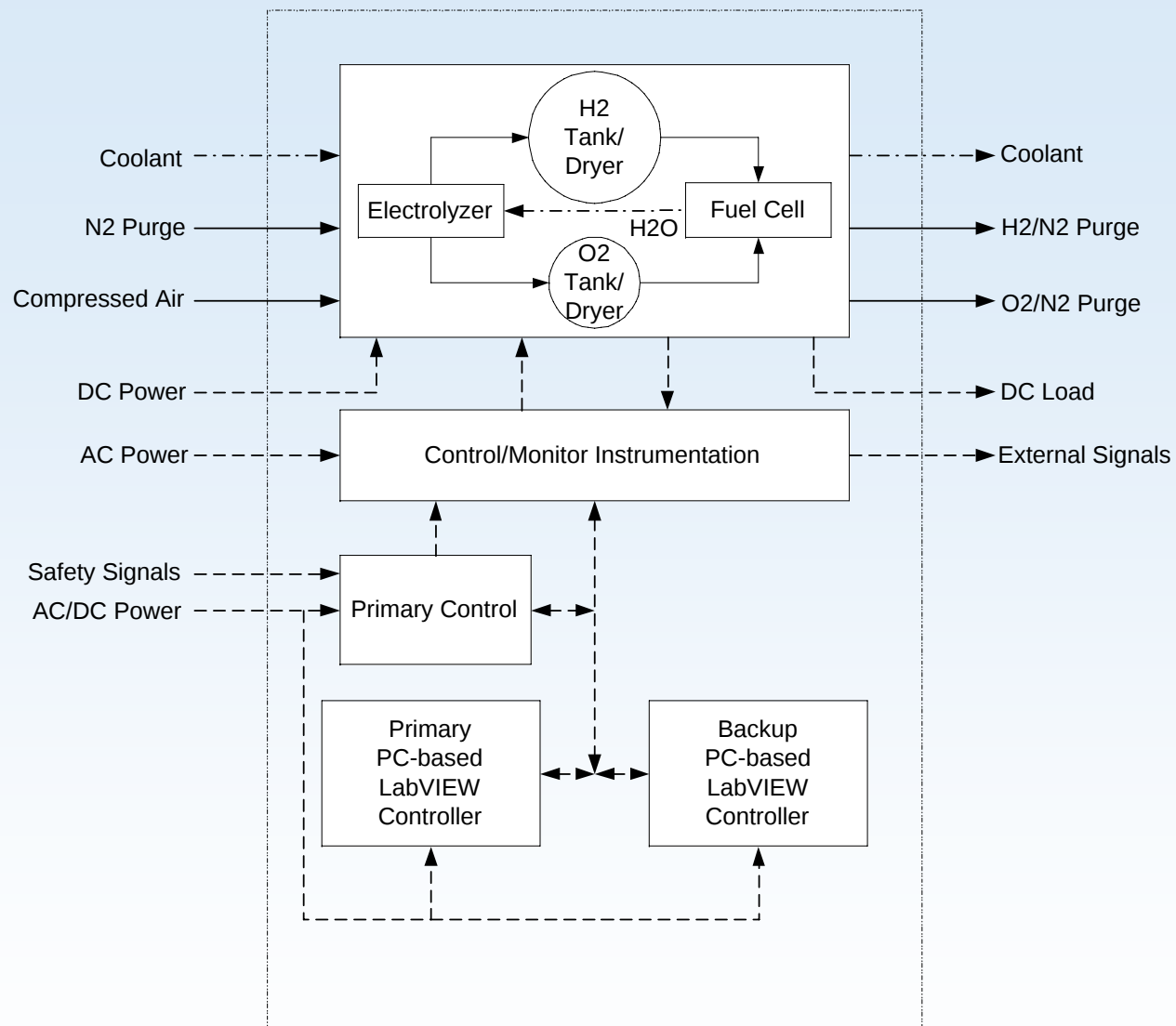
Presentation to 1st European Fuel Cell Technology & Application Conference
Rome Italy 14 Dec 2005

Presented by Luca Andreassi for B.J. Chang



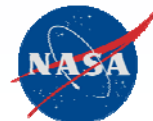
Overview

- Hydrogen Oxygen Regenerative Fuel Cell System built at NASA Glenn
- Polymer Electrolyte Membrane technology based
- Fully closed cycle designed for high altitude solar aircraft
- 5 kW discharge rate, 0-15 kW charge rate, nominally 60 kWh storage capacity
- Demonstrated 5 continuous charge discharge cycles back to back without breakdown



Regenerative Fuel Cell - Process Block Diagram

Glenn Research Center at Lewis Field



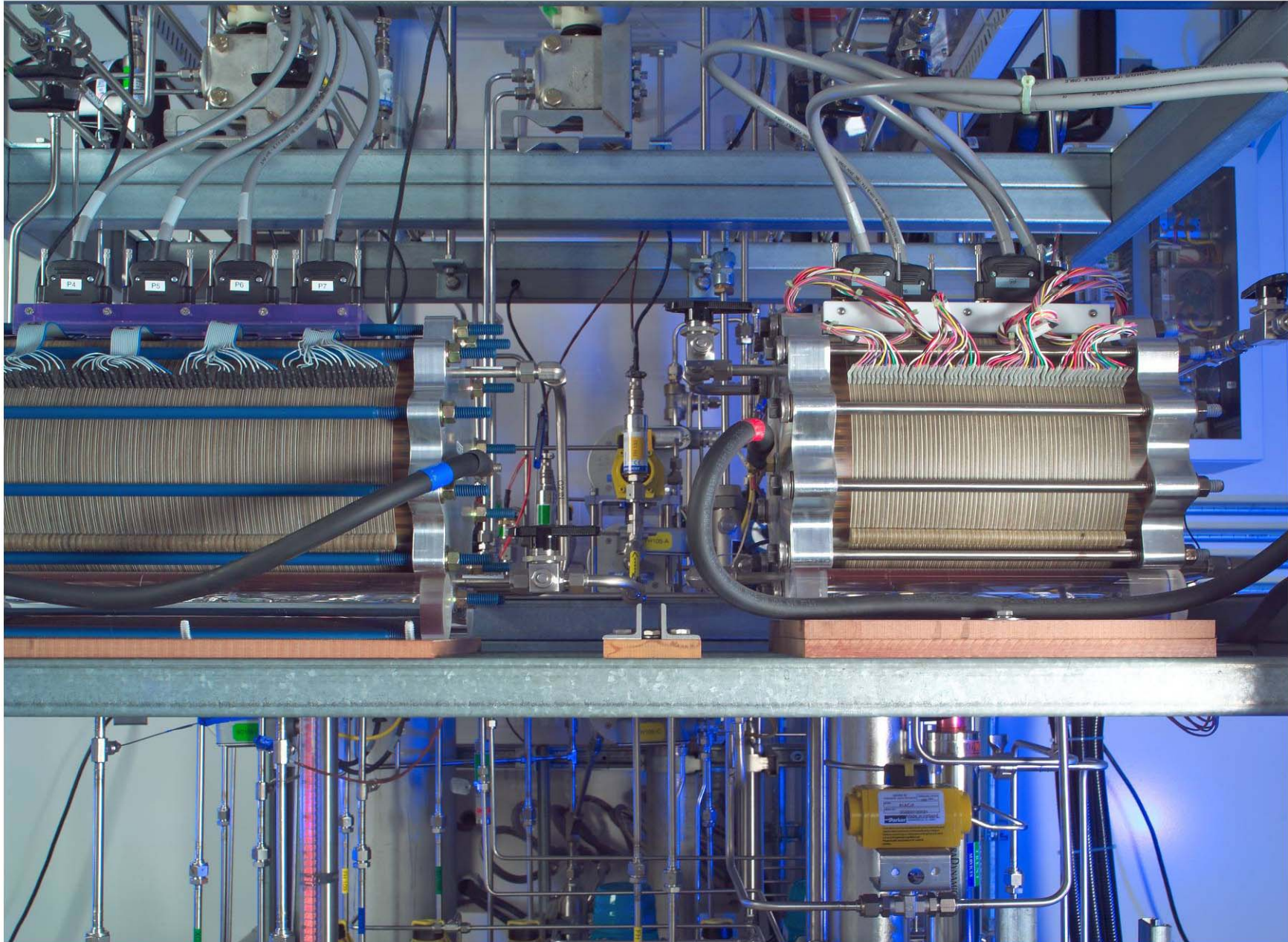
Regenerative Fuel Cell System Breadboard



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C-2005-766



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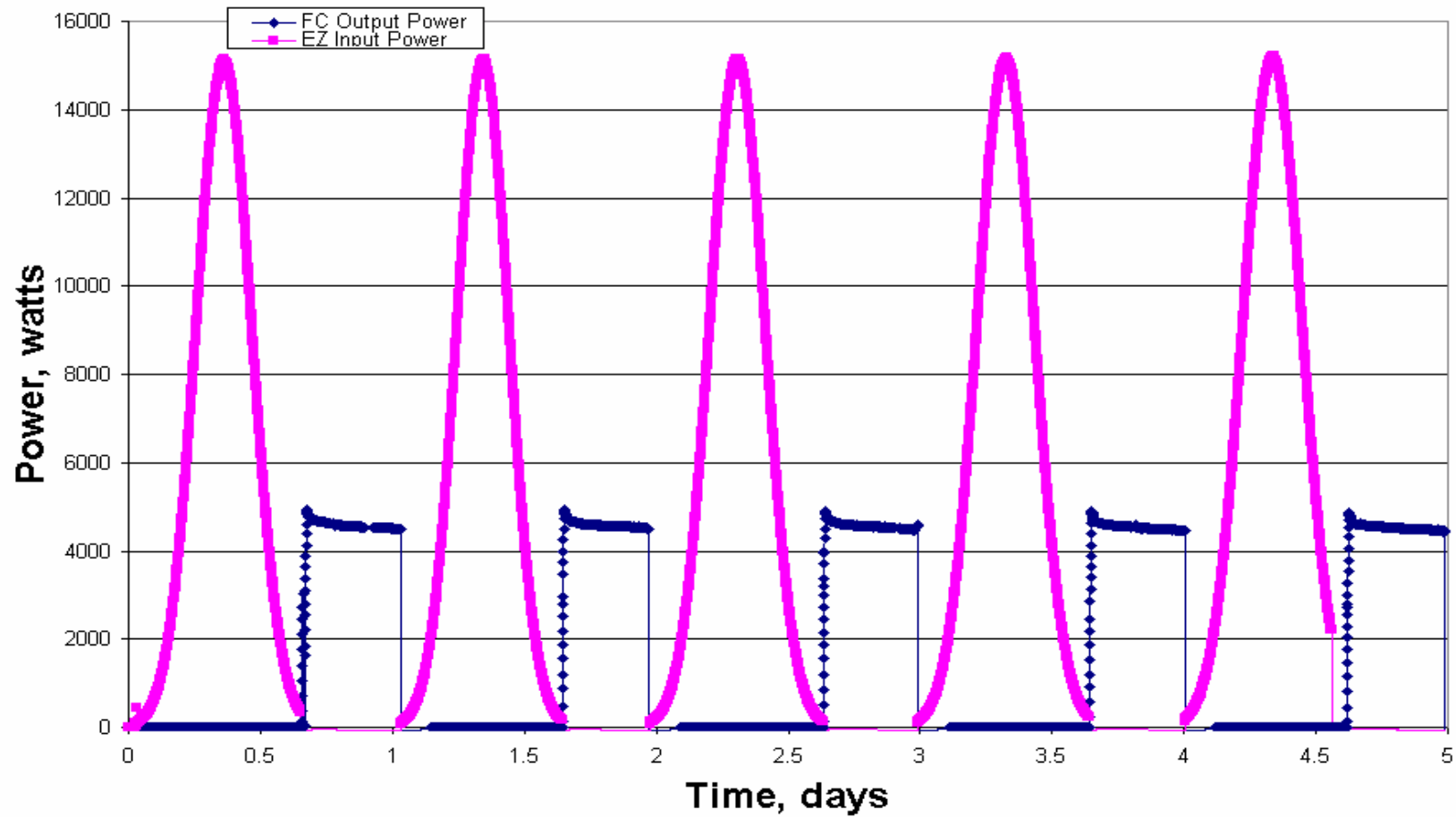


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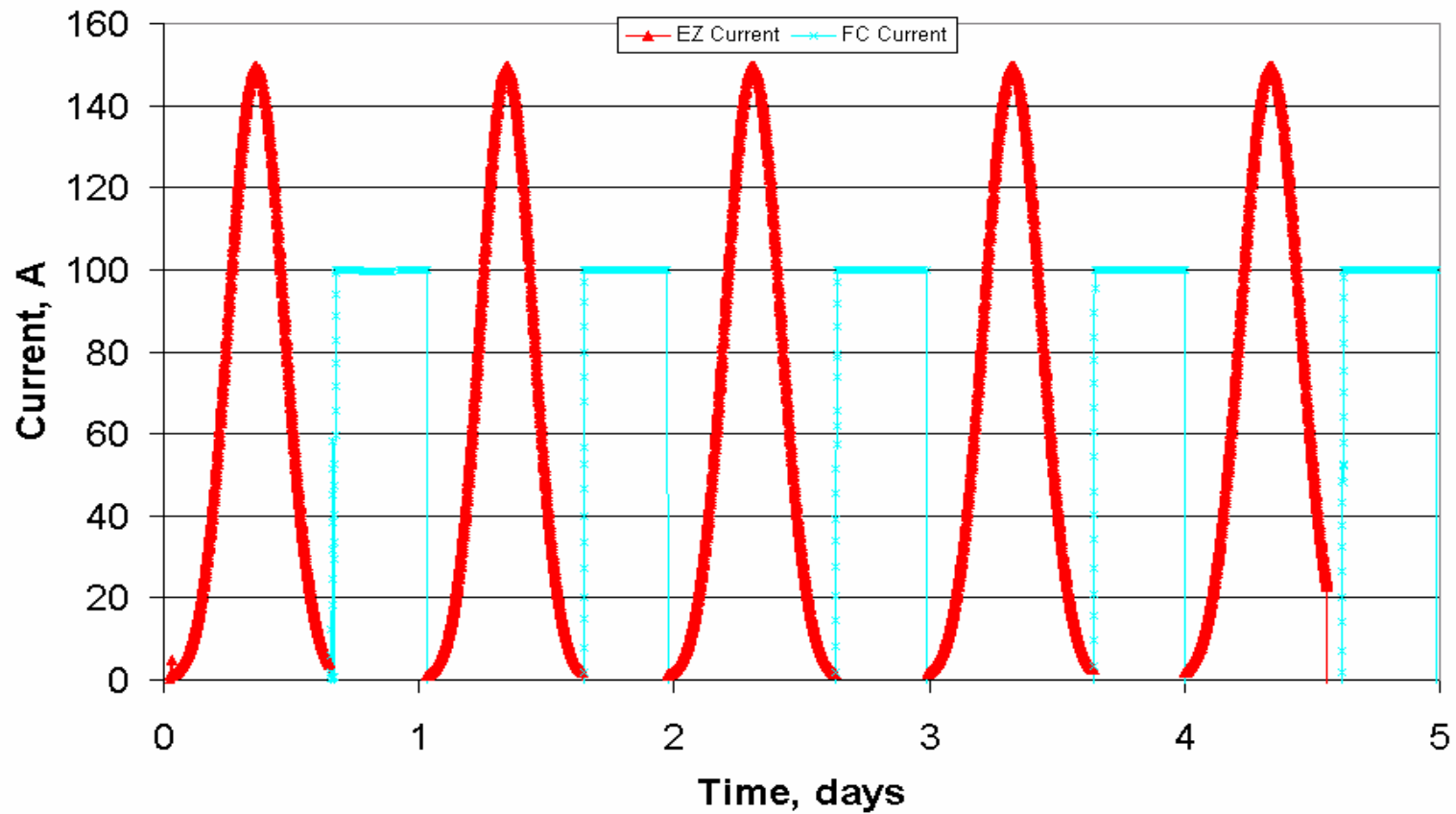


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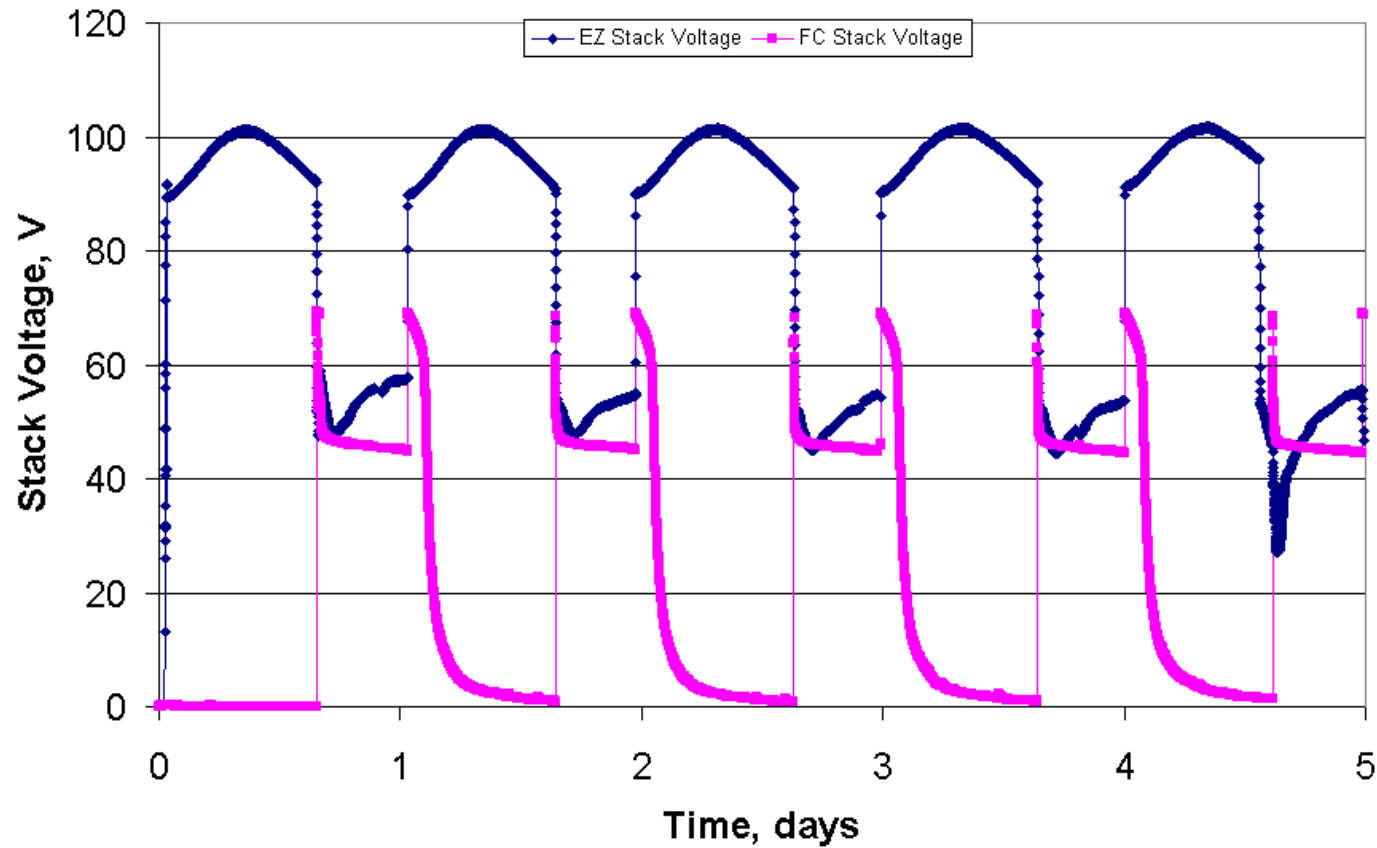
Input and Output Power of RFCS versus Time



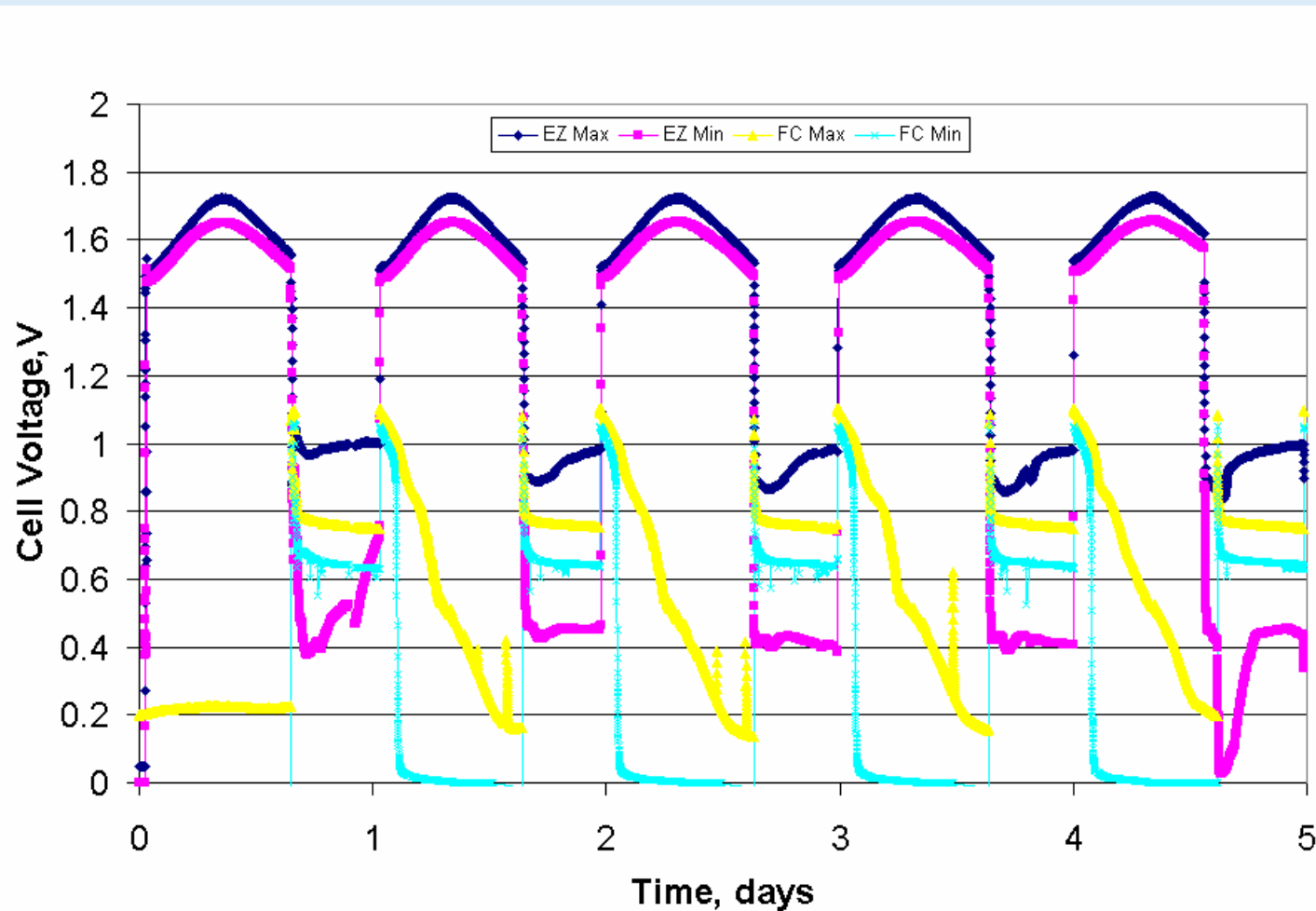
Fuel Cell and Electrolyzer Stack Current versus Time



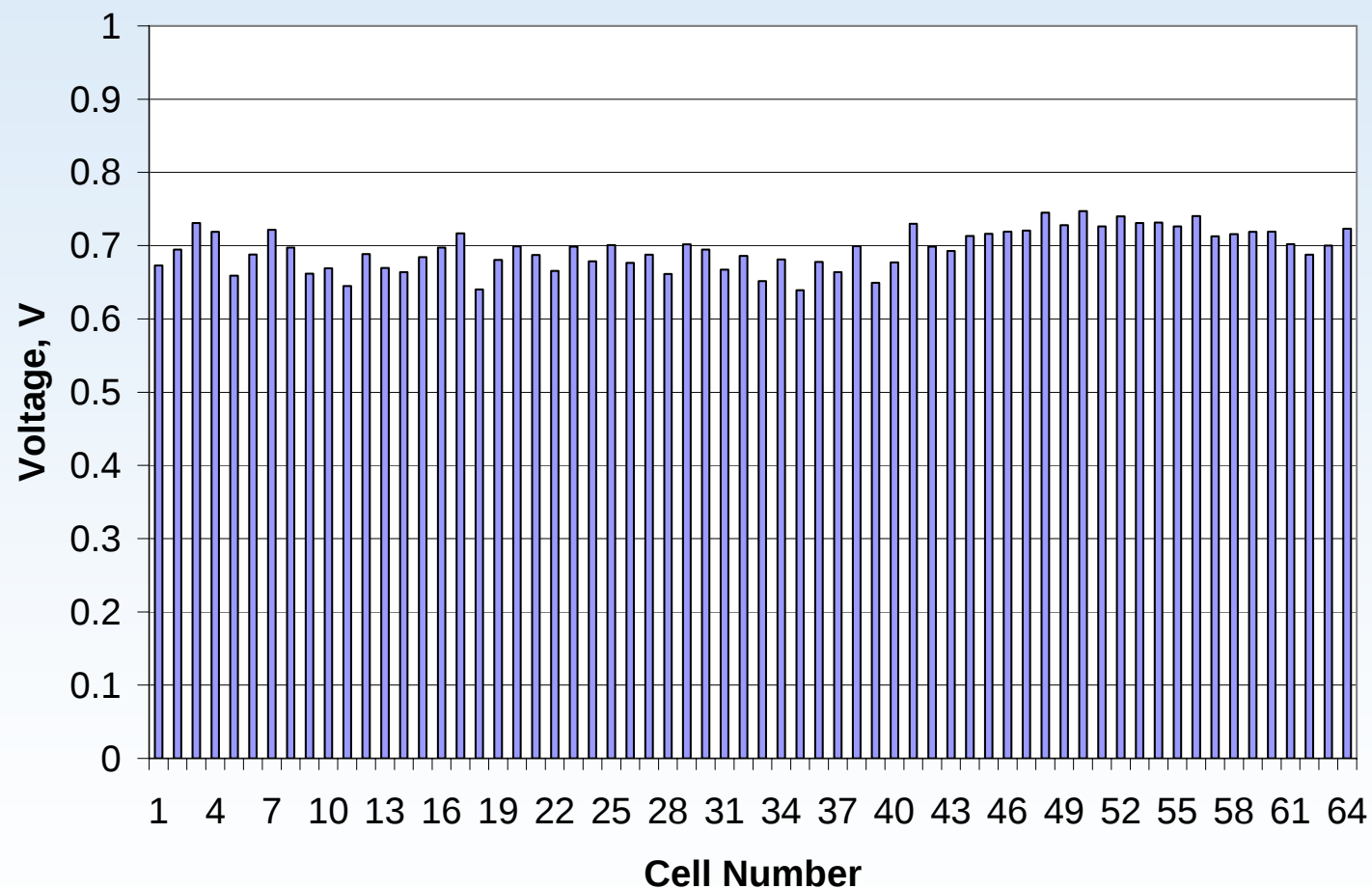
Fuel Cell and Electrolyzer Stack Voltage versus Time



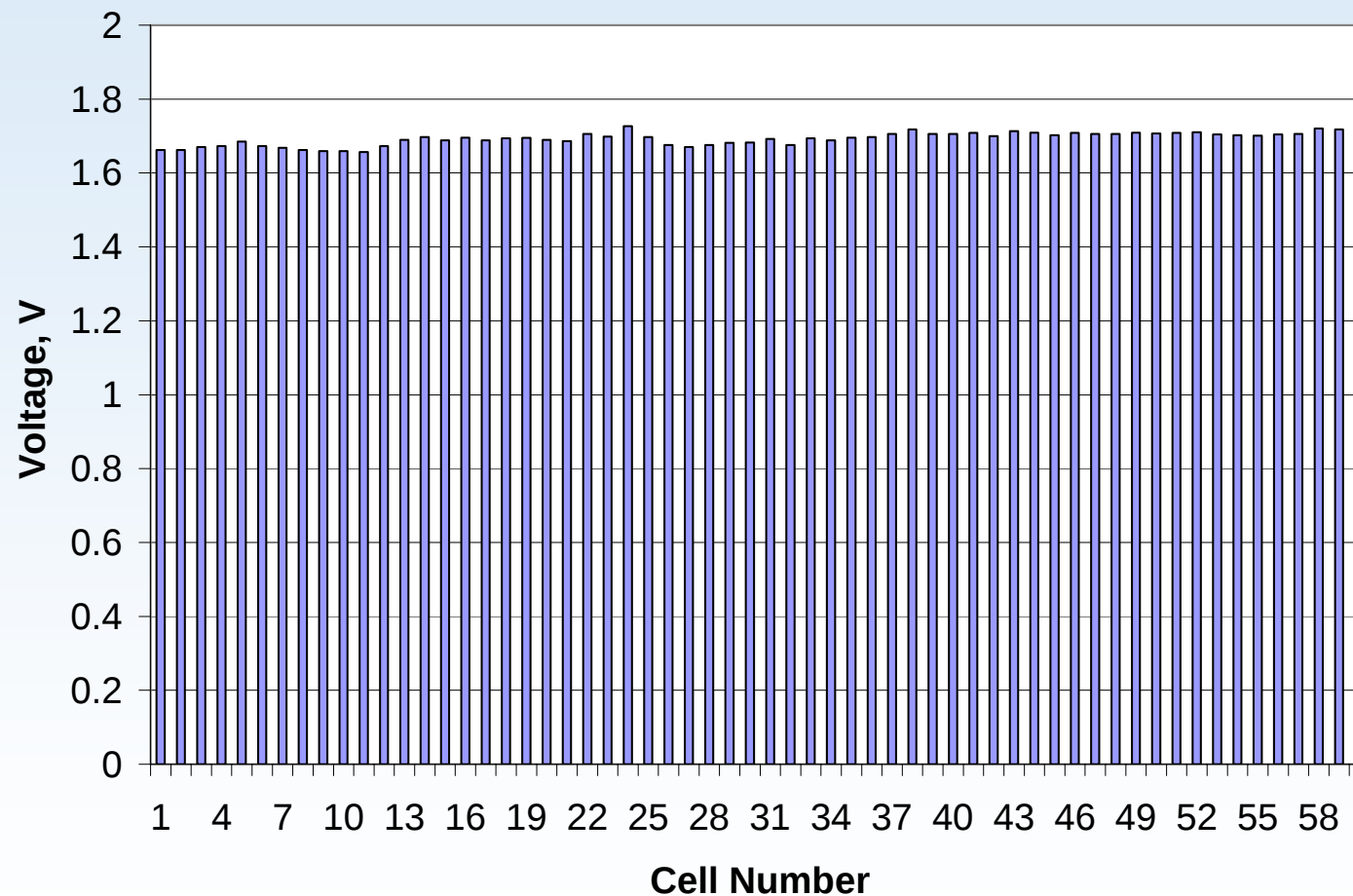
Fuel Cell and Electrolyzer Maximum and Minimum Cell Voltage



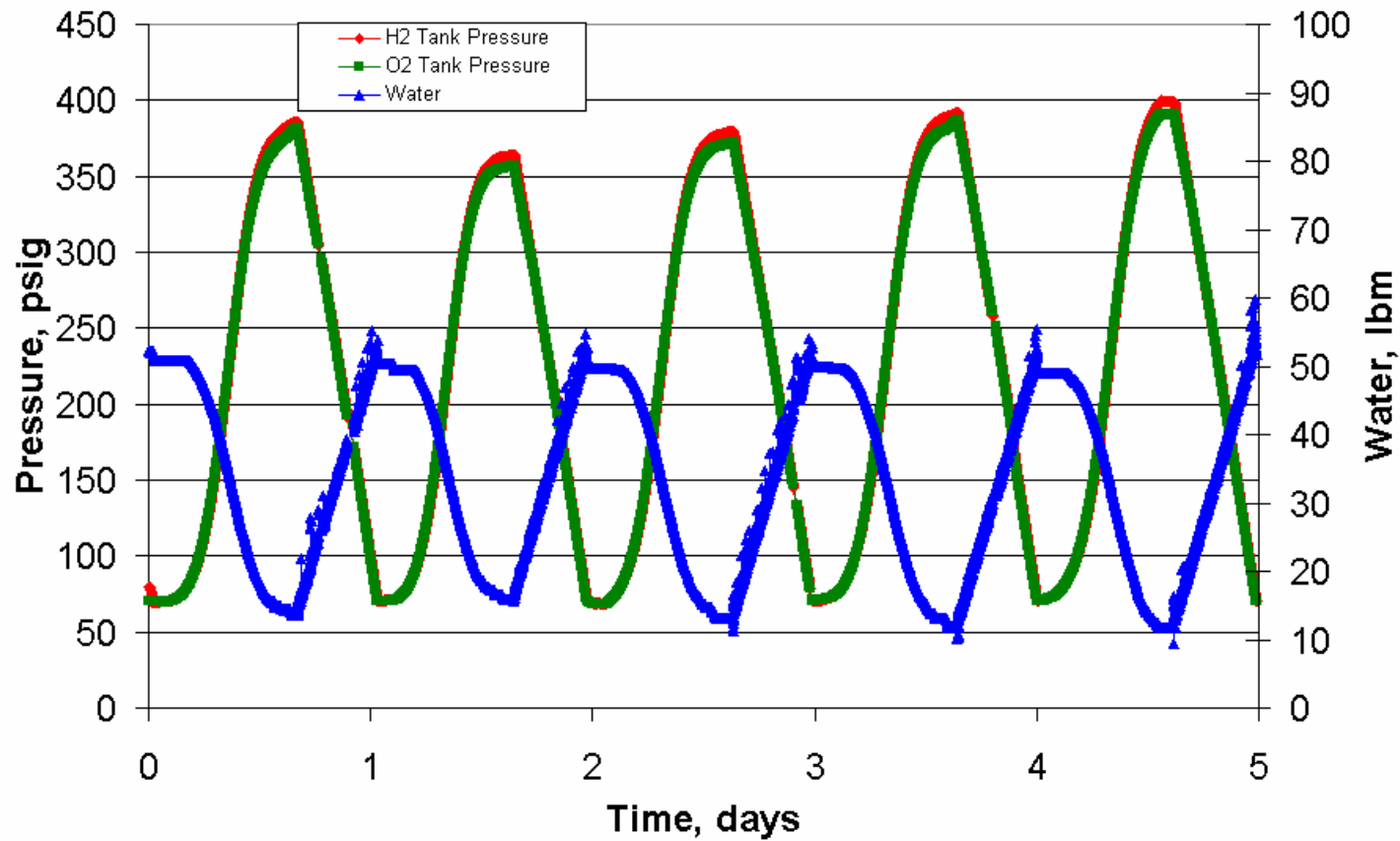
Fuel Cell Individual Cell Performance at 100A, 65 psig and 135oF



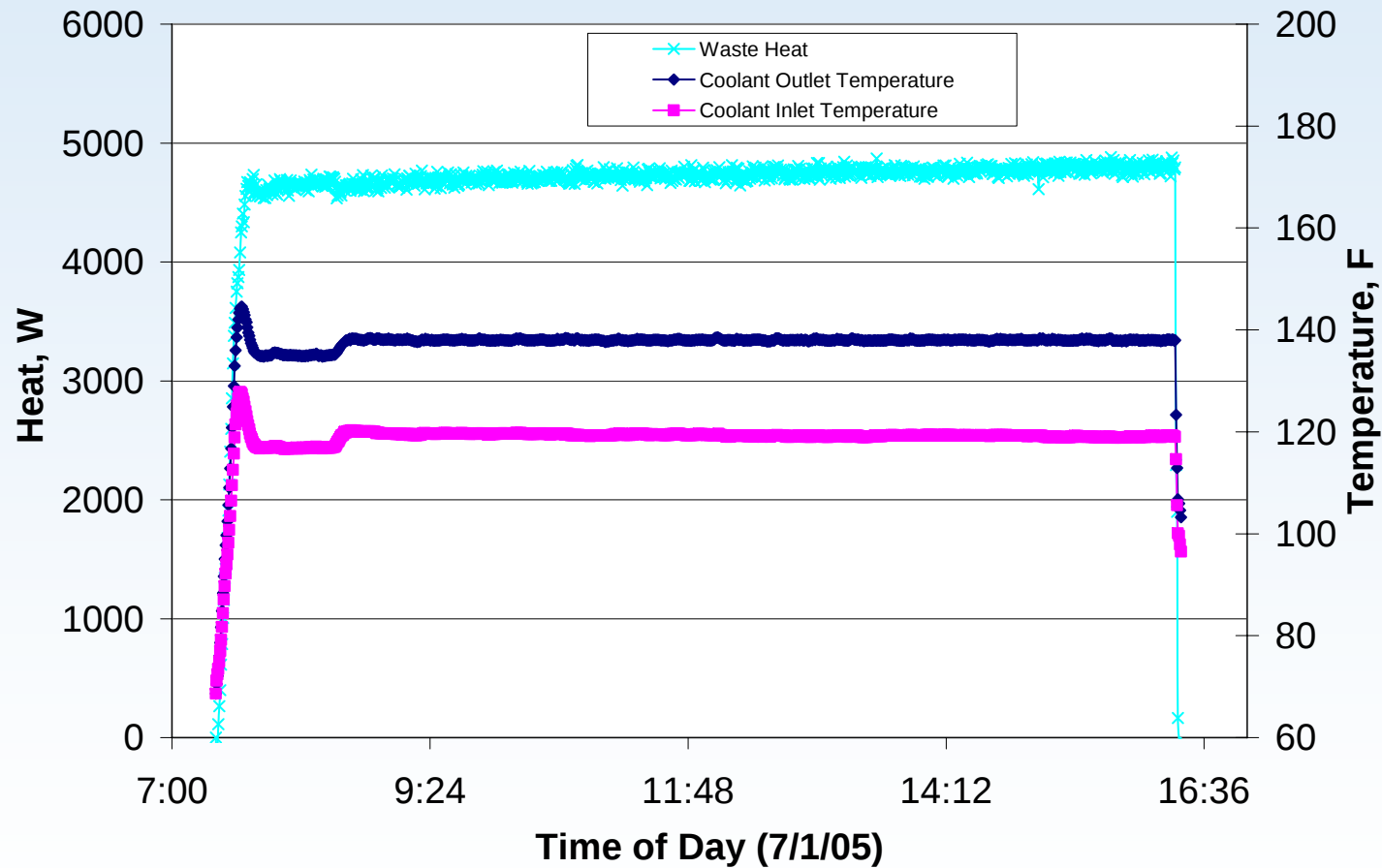
Electrolyzer Individual Cell Performance at 150 A, 245 psig and 140oF



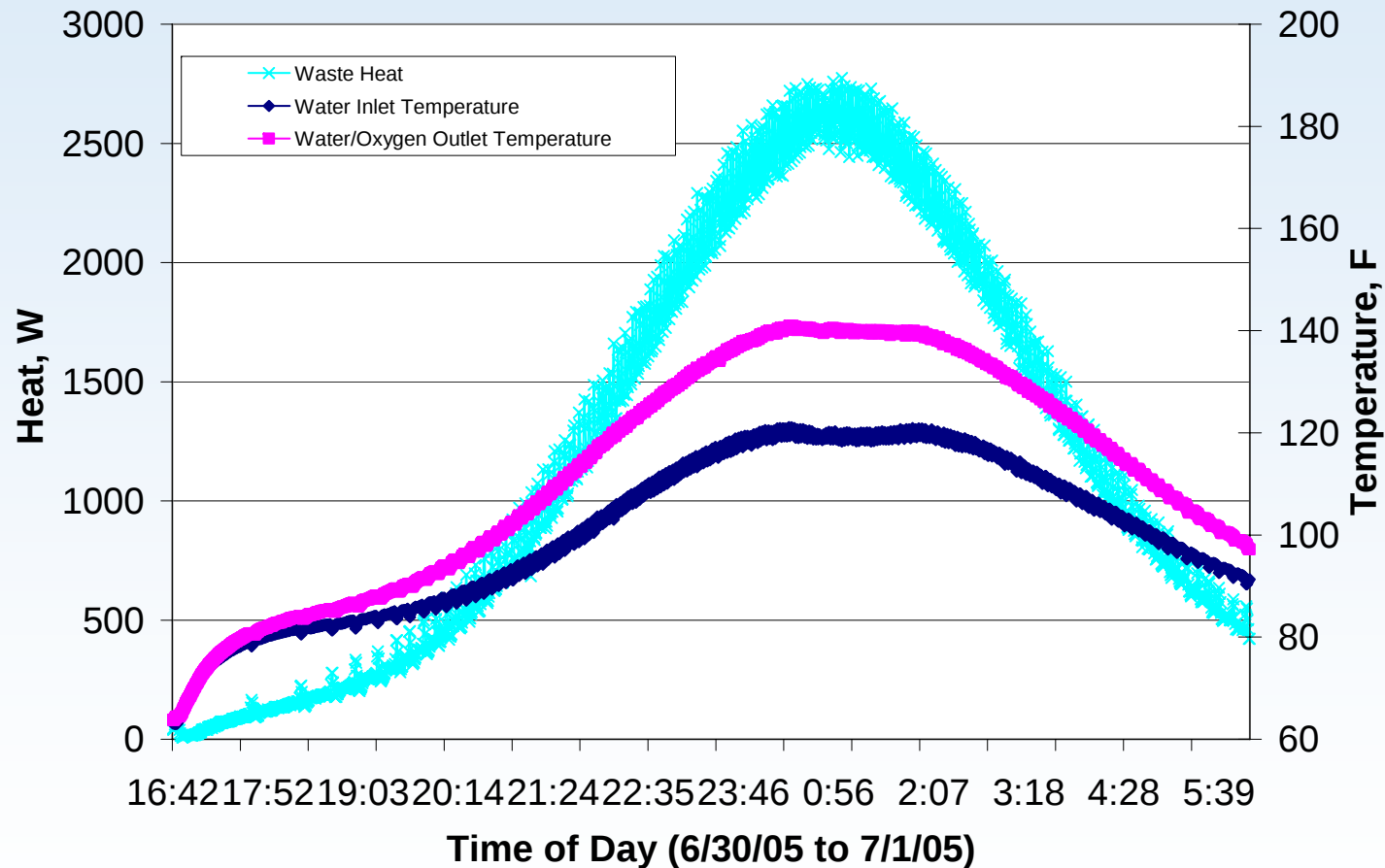
RFCS Gas and Water Material Balance



Fuel Cell Thermal Control Performance in 5th Cycle



Electrolyzer Thermal Control Performance in 5th Cycle



Summary

- First ever demonstration of fully closed cycle H₂-O₂ regenerative fuel cell
- Seven complete charge/discharge cycles, last five were completed back-to-back
- At end of 5th cycle, system was fully capable of repeating one more cycle
- System ran fully closed loop at full power without breakdown
- 40 % RTE achieved at maximum power
- 50 % RTE demonstrated at reduced power in another test reported elsewhere

Why we are doing it ?

- Key technology that enables future NASA missions
- Solar energy storage system of choice for day/night cycles greater than 4 hours.
- Applicable to a wide variety of space and planetary surface missions as well as high altitude solar electric flight.

**Lunar Base, solar
W/ regenerative fuel cell**



**Mars Rover Solar Aircraft
W/ regenerative fuel cell**



**Mars Base Camp, solar
W/ regenerative fuel cell**

