Reformate Stack Operation Issues and Improved Designs

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Objectives

- **Subtask 4.1 Corrosion Cell for Evaluation of Bipolar Plate Materials**
  - **Develop a screening tool for evaluating candidate bipolar materials**

- **Subtask 4.2 Explore cold-start dynamics of a PEM stack**

- **Subtask 4.3 Improved Stack Diagnostics**
  - **Incorporated in cold-start studies**

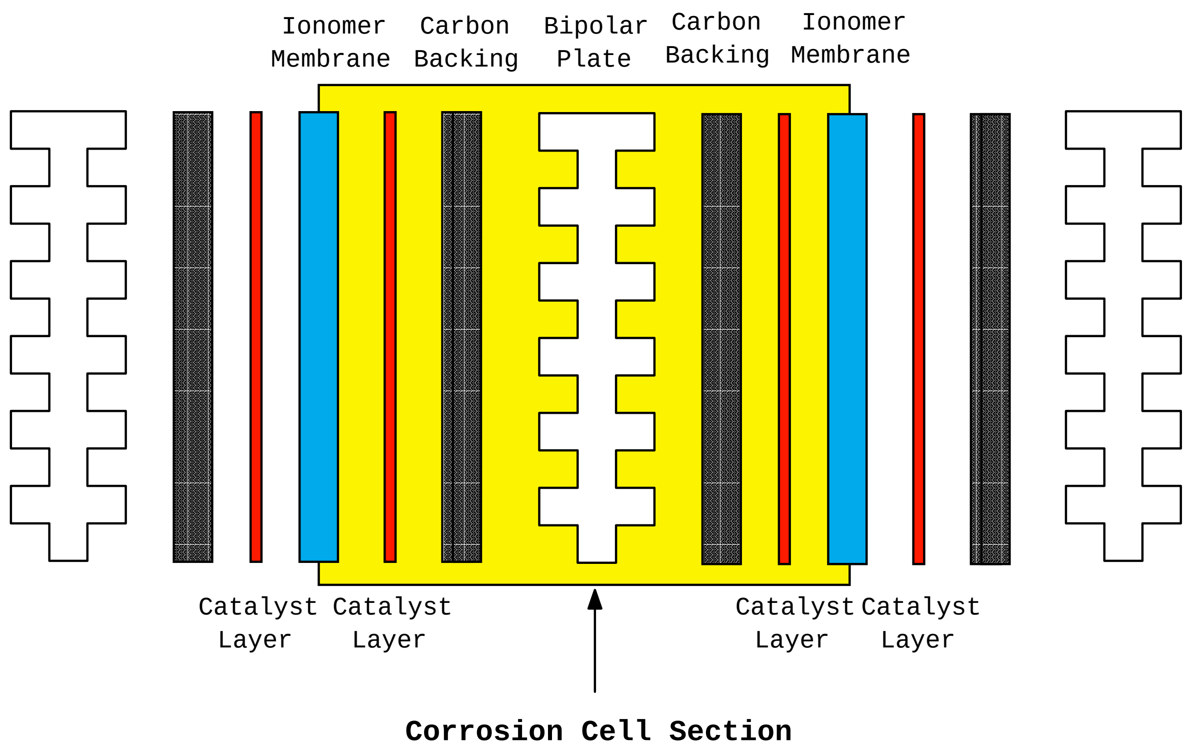
- **Subtask 4.4 Hollow Fiber Fuel Cell Concept**
  - **Presented as Poster**

Corrosion Cell Concept

•APROACH

-Simulate anode and cathode conditions

-Measure long term contact resistance and ions release into solution



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Corrosion Cell Progress Summary

- **Summary of progress**
  - -Began as summer student project in 1998
  - -Continued at low level
  - -Materials previously evaluated:
    - **- 316 SS, high nickel alloys, Ti and TiN coatings**
  - -**Materials evaluated in FY 2000**
    - -**Carbon/carbon composite (T. Besmann - Oak Ridge)**
    - -**Carbon/Polymer composite (SGL Carbon)**
    - -**Gas phase nitridation of alloys (M. Brady - Oak Ridge)**
- **Milestones**
  - -Sept 00 Complete transfer of technology

4.2 Cold-Start Dynamics

APPROACH

- **Develop a global model of heat requirements and water transients during start-up from sub-freezing temperatures**
- **Experimentally verify two cases**
  - **Auto-thermal startup applicable to stored hydrogen**
  - **Startup with coolant heated by fuel processor waste heat**

Cold-Start Dynamics
Summary of Progress

- **Completed test apparatus in environmental chamber (-40°C)**
- **Two transient models developed**
  - **Auto-thermal cold-start**
  - **Cold-start with fuel processor waste heat**
- **Initial cold-startup tests performed with 12 cell stack from Energy Partners**
- **Auto-thermal startup planned**

Cold-Start Dynamics
Summary of Progress (Continued)

- **Original Milestones**
  - **March 00 Complete first series of cold-start tests**
    - **Completed April 00**
  - **June 00 Complete experiments with contaminants at sub-ambient temperature and develop start-up strategy**
    - **Sept 00 Perform tests after initial data from single cells is available from MST-11**
- **Future Plans**
  - **Sept 00 Complete auto-thermal cold-start tests**
    - **Use electrochemical impedance methods to characterize the stack and individual cells during steady-state and transient operation**
- **Industrial Interactions**
  - **Worked closely with Energy Partners**
  - **Transient cold-start models are available to industry**

Auto-Thermal Model Basis

- **Assumptions**
  - Stack Model without coolant system
  - Based upon measured polarization curves down to -10^{o}C
  - Below -10^{o}C, curves are estimated
  - Dry air available from compressor at 78^{o}C (isentropic compression from -40^{o}C)
  - Gases leave at 100% relative humidity
  - Bipolar plates are thermally isolated from end plates

- **Solution**
  - Applied Engineering Equation Solver (EES) by F-Chart Software

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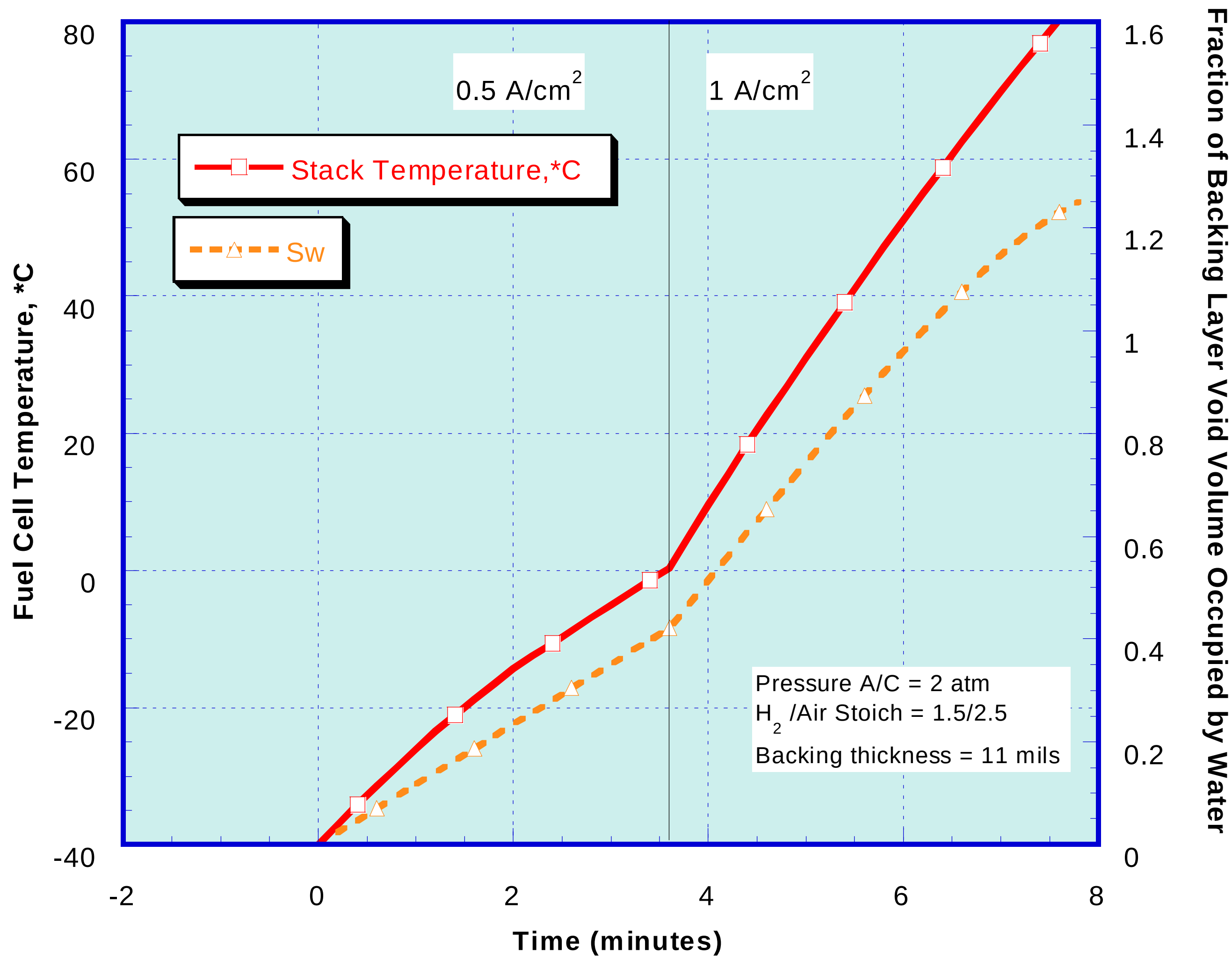
Auto-Thermal Cold-Start Predictions
Water Saturation with Stepped Current



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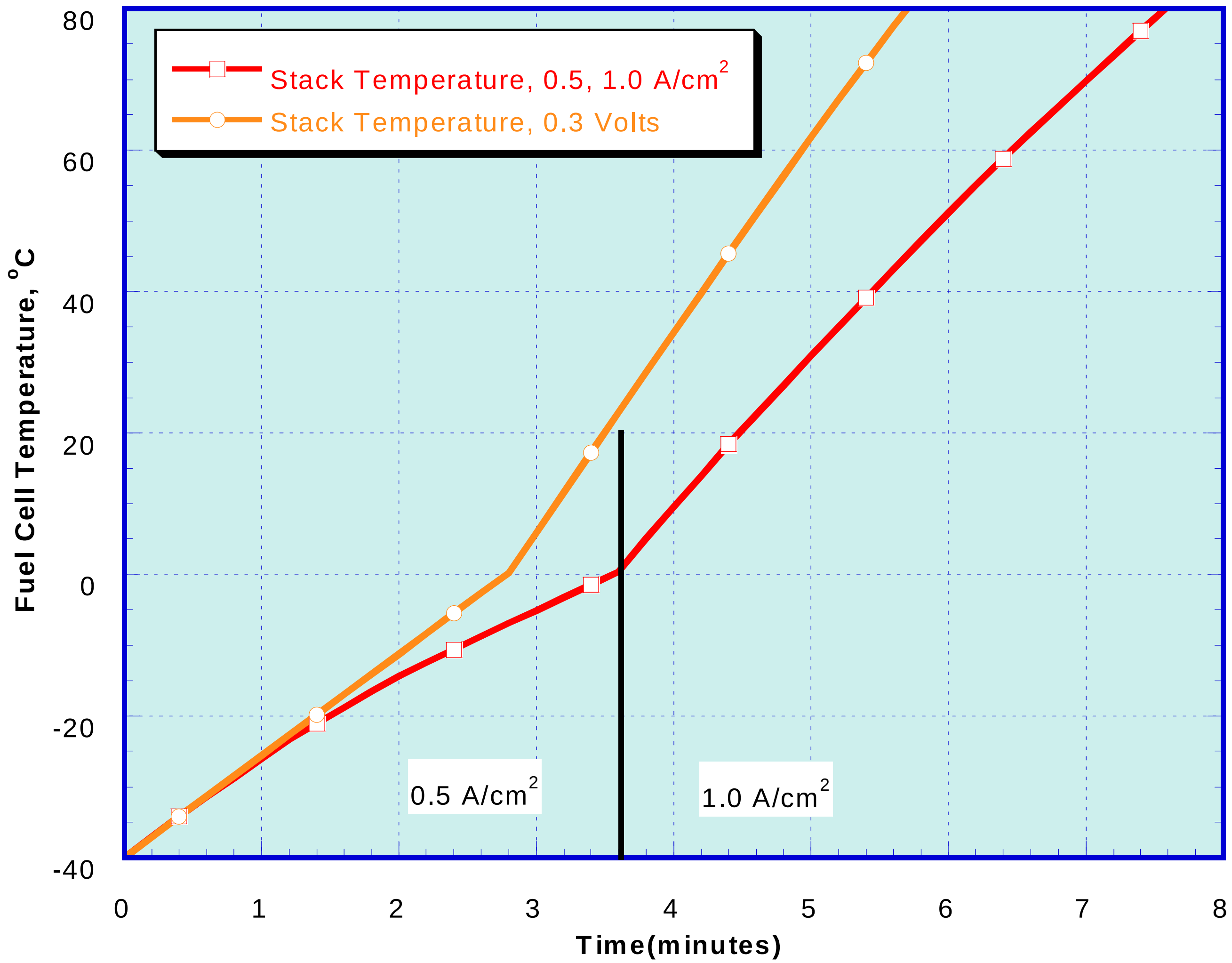
Auto-Thermal Cold-Start Predictions
Current vs. Voltage Control



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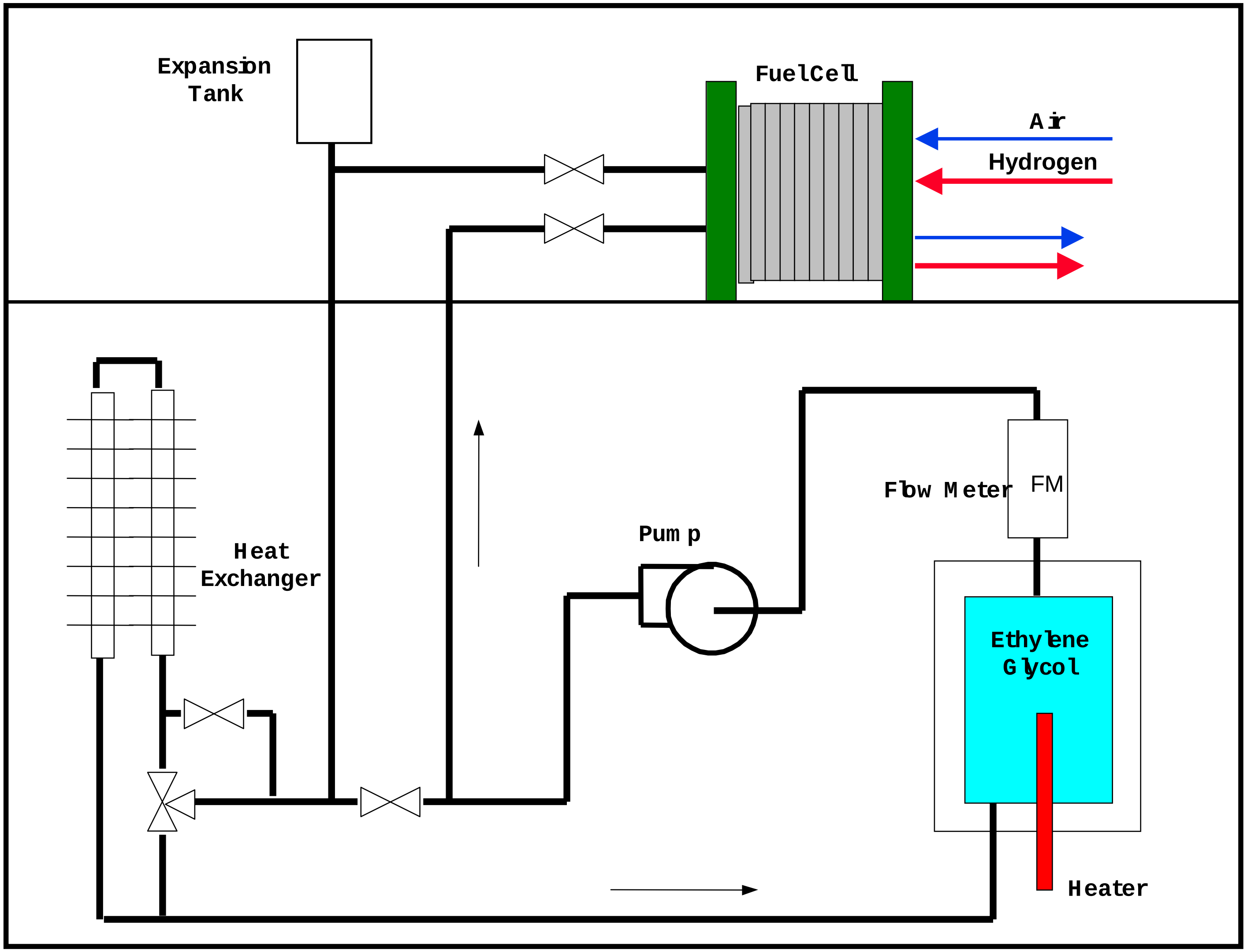
Cold-Start Dynamics
Cooling System with External Heat Source



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Experimental Set-up For Cold Start-Up Measurements

- Stack, coolant loop cooled to -40^{o}C
- Test run in -40^{o}C air bath

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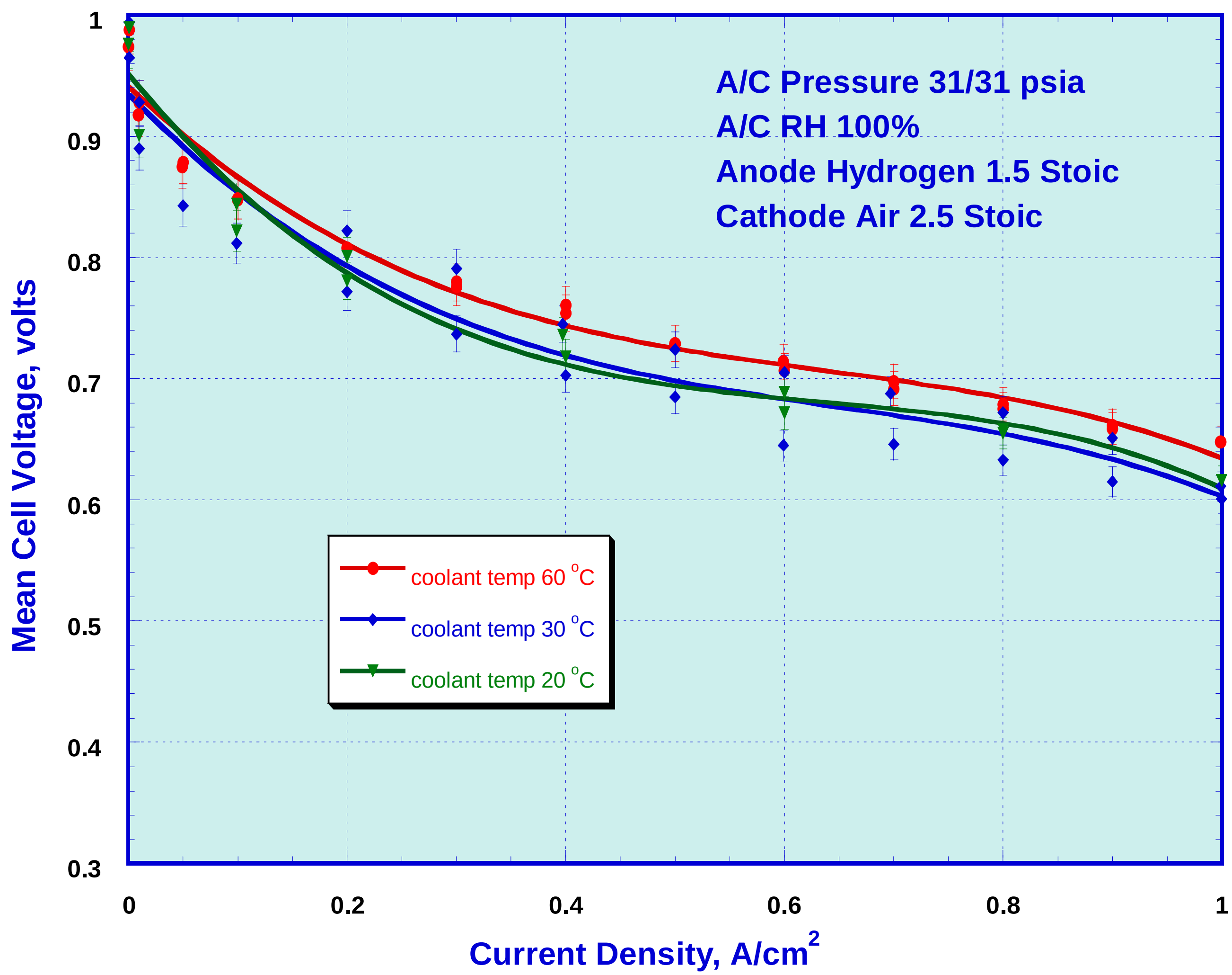
Measured Polarization Curves For 12-Cell Stack From Energy Partners



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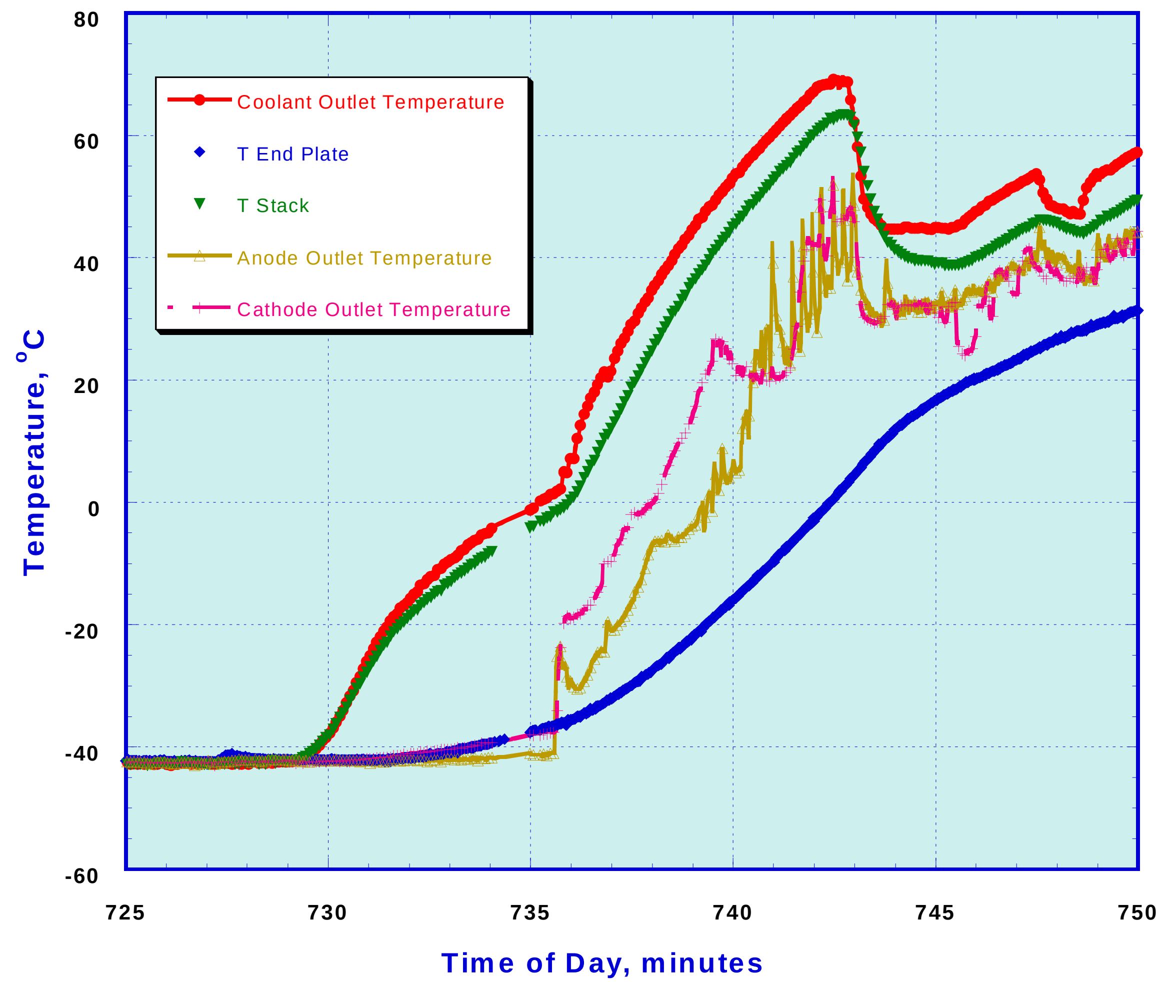
Temperature History During Cold Start-Up of Energy Partners Stack



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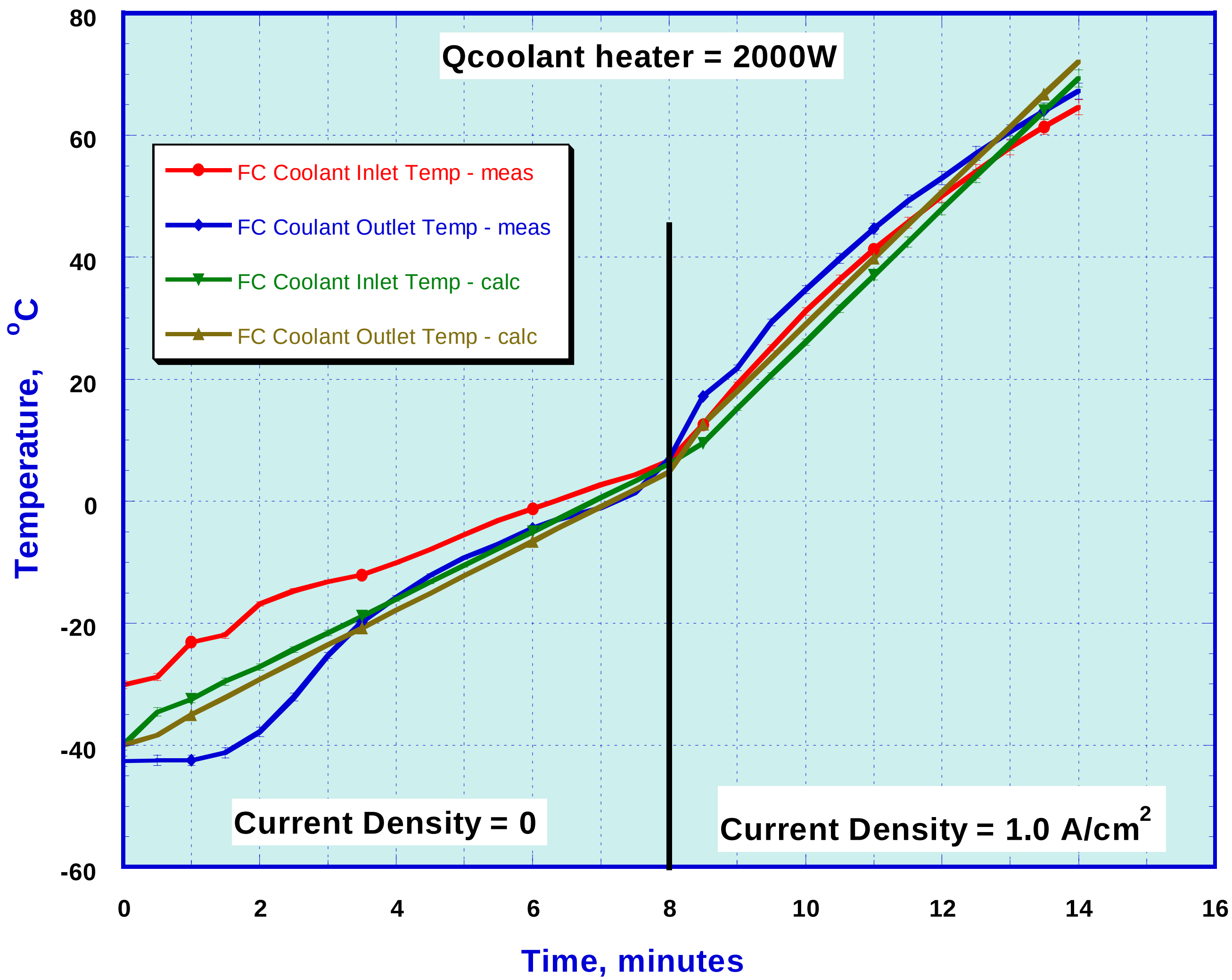
Validation of Fuel Cell / Coolant System Model



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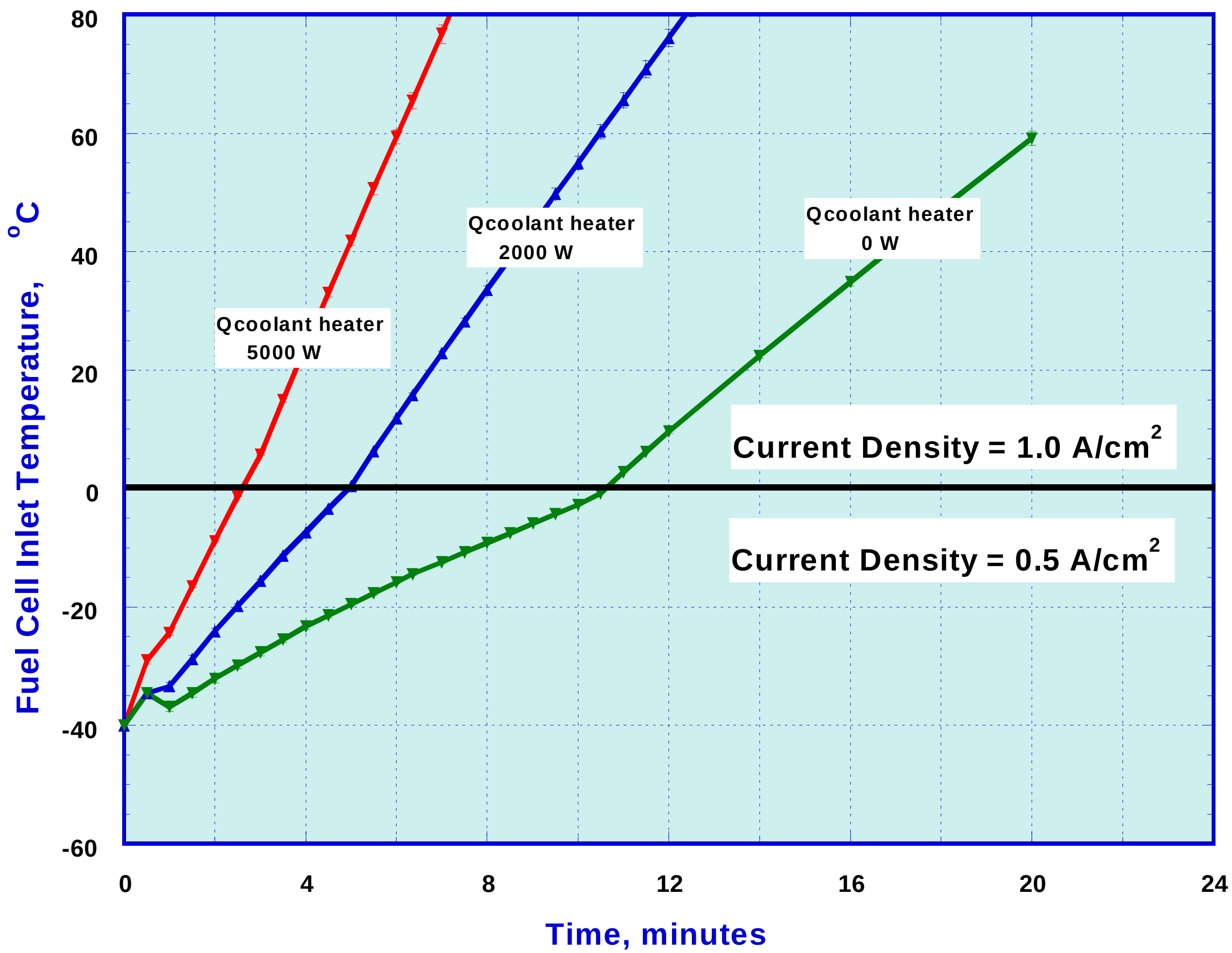
Model Predictions for Fuel Cell /Coolant System



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Design and Operating Guidelines to Minimize Cold Start-Up Time

Auto-Thermal Start-up

- Reduce thermal load of end plates
- Operate with constant low stack voltage to maximize stack heat production
- Air Preheat through compression provides small benefit
- Dry gas feed streams are required up to $0^{o}C$

Addition Fuel Processor Heat Source Issues

- Minimize thermal mass of auxiliary flow loop
- Faster Start-up times require less cooling system thermal mass or a larger external heat source