2004 DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program Review Presentation

Development of a Thermal and Water Management (TWM) System for PEM Fuel Cells

Chung Liu

Honeywell International, Inc.

May 26, 2004; Philadelphia, PA

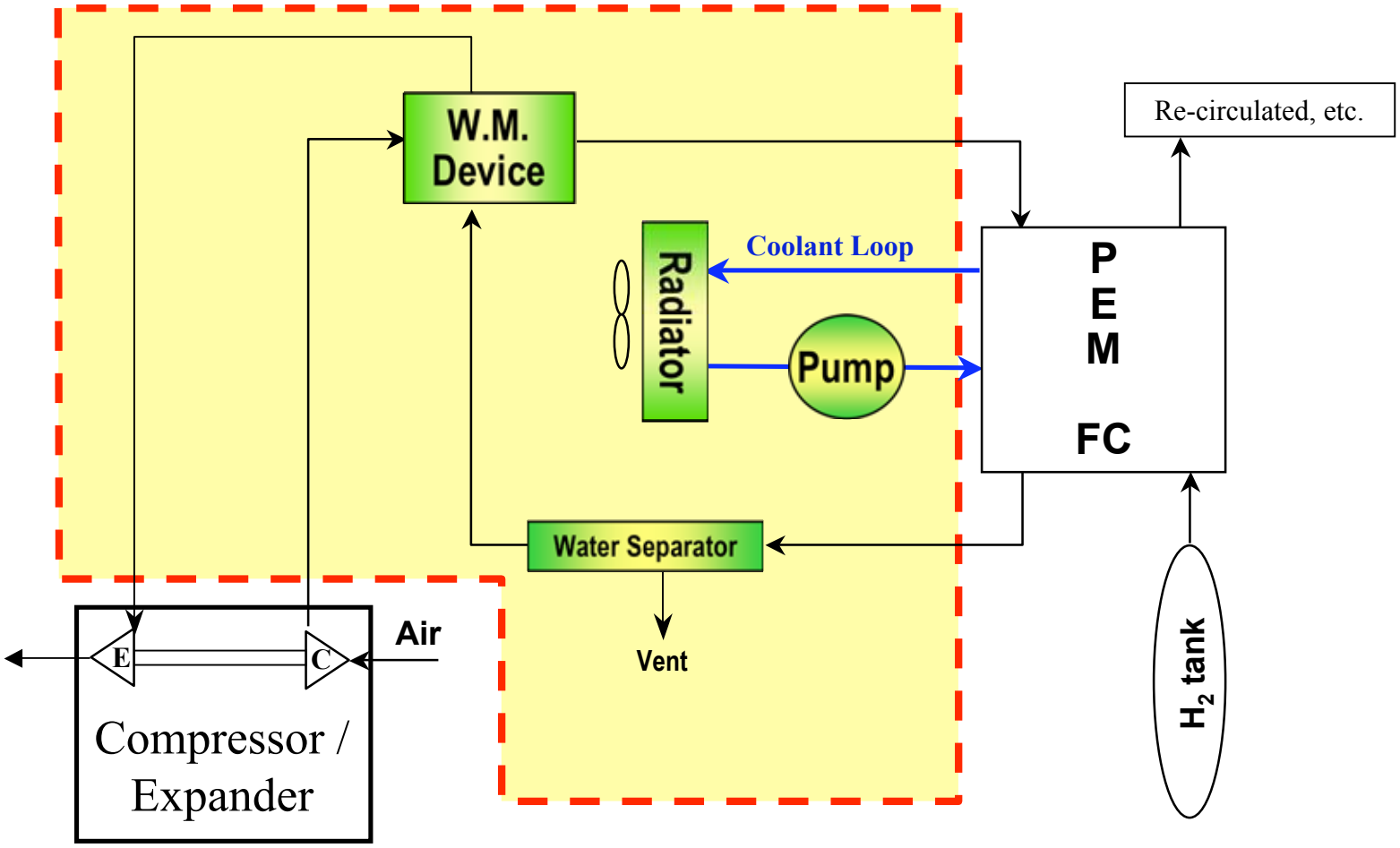
This presentation does not contain any proprietary or confidential information.

Project Objectives

To assist DoE in developing a humidification and cooling system for PEM Fuel Cells in transportation applications

- To focus on cathode humidification for a 50 kW FC power system
- To study pressurized TWM system performance
- To analyze steady-state automotive operation conditions for comparison of concept schematics
- To establish TWM system / component specifications
- To demonstrate the performance of a breadboard TWM system with research hardware

Thermal and Water Management System



Budget

FY	$Total	$DOE Share	$Honeywell Share
2004	$1.23M	$982K	$248K
2005	$1.87M	$1.5M	$370K
2006	$1.00M	$768K	$232K
Total	**$4.1M**	**$3.25M**	**$850K**

DoE: 80% HON: 20%

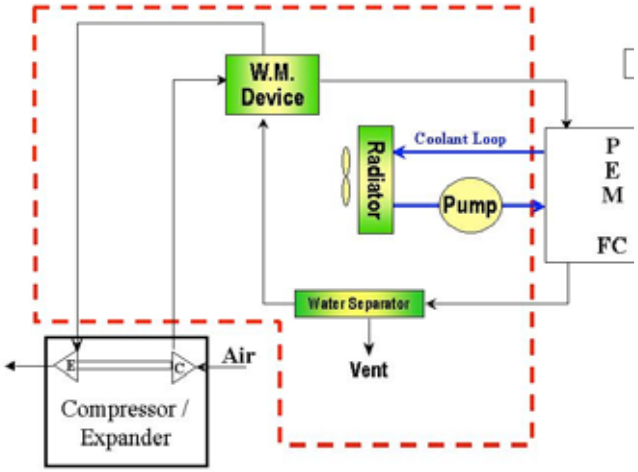
Technical Barriers and Targets

- **Technical Barriers:** **HFCIT Program Multi-Year Program Plan**
  C. Thermal Management (Transportation system)
  R. Thermal and Water Management (Component)
  - Capacity to reject low temperature FC stack waste heat
    - Utilize Honeywell core technology of aerospace heat exchangers
  - Water balance (humidification & exhaust water recovery)
    - Evaluate different water management concepts and devices
- **Current Development Priority**
  - Size: 5 (most critical)
  - Reliability: 4
  - Cost: 3
  - Power consumption: 2
  - Weight : 1

Targets to be established based on DoE fuel cell power system requirement

Approach

- **Analytical system simulation**
  - Compare 4 different schematics using
    (1) adsorbent wheel,
    (2) membrane humidifier,
    (3) porous plate, and
    (4) cathode recycle respectively



- **Water management development**
  - Balance water vapor and heat transport
  - Avoid (or minimize) H_2O phase change for air humidification
- **Thermal management component**
  - Utilize aerospace designs and automotive manufacturing processes
  - Evaluate other advanced heat exchanger technologies
- **System integration and demonstration**
  - Demonstration tests with fuel cell simulator

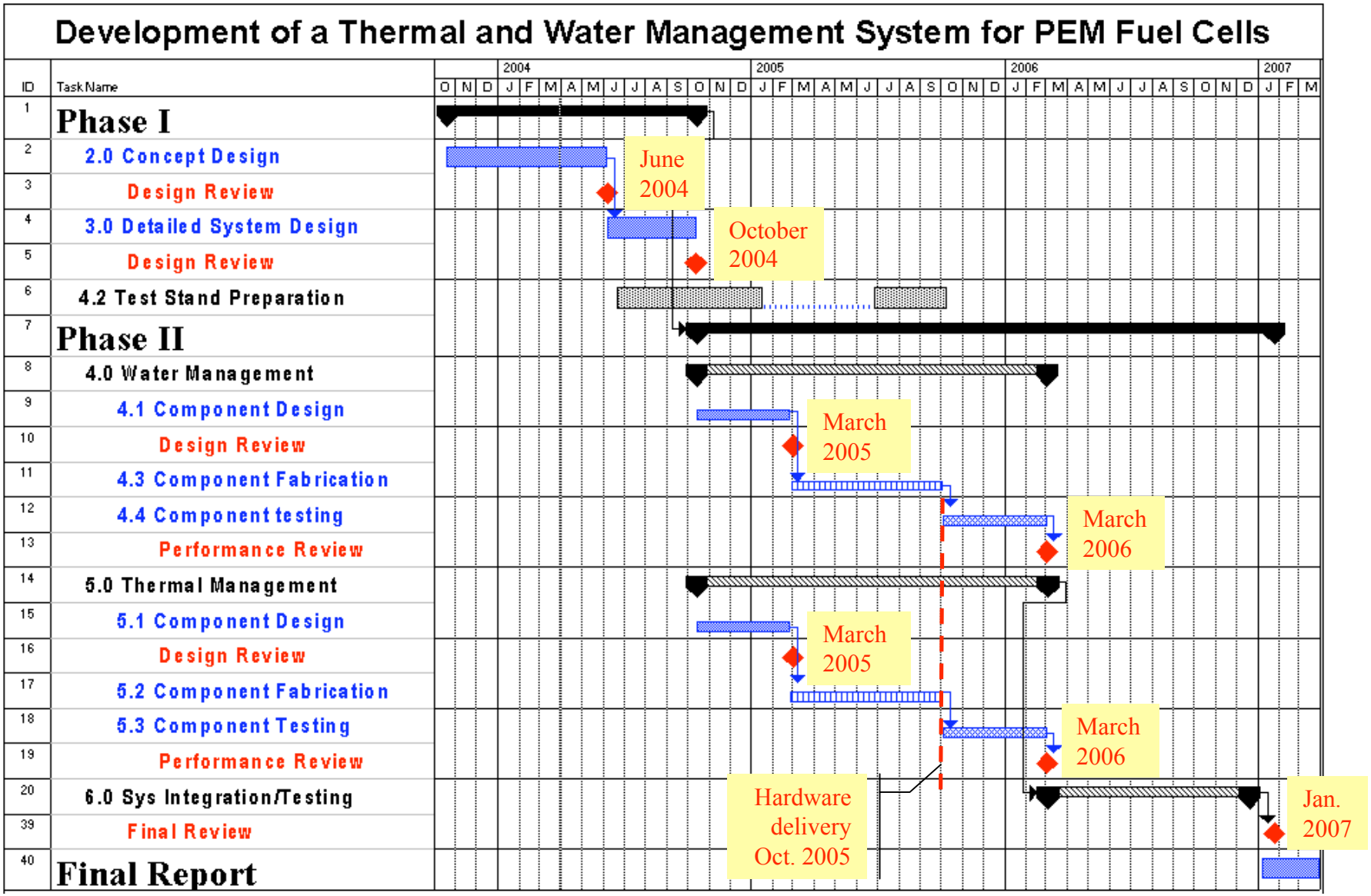
Facility Related (Honeywell Safety Standard)

- The Honeywell Torrance site utilizes a variety of safety techniques in the design of equipment and analysis of potential hazards such as Hazard & Operability Study (HAZOP), FMEA and What If analysis.

- Hazardous Materials, Processes and Operation practice (Form 3134) applies to the use of hazardous materials at Torrance. The New Chemical Approval Request Form is used to assure a knowledgeable Honeywell Safety & Environment person reviews each new chemical.

- All Torrance personnel receive Cal-OSHA regulatory compliance training each year. Additional specialized safety training is also given to certain technicians or crafts.

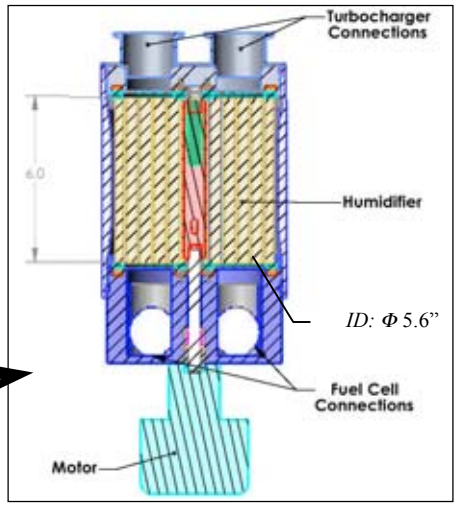
Project Timeline

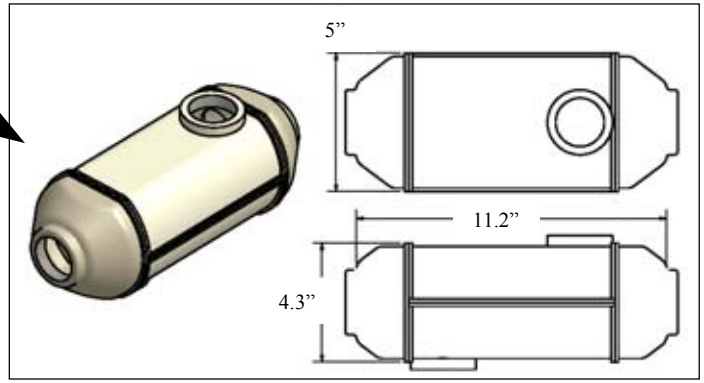


Technical Accomplishments / Progress

Next 6 slides:

- FC and compressor interfaces
- Concept analysis
  - adsorbent wheel
  - membrane humidifier
  - porous metal foam humidifier
  - cathode recycle compressor





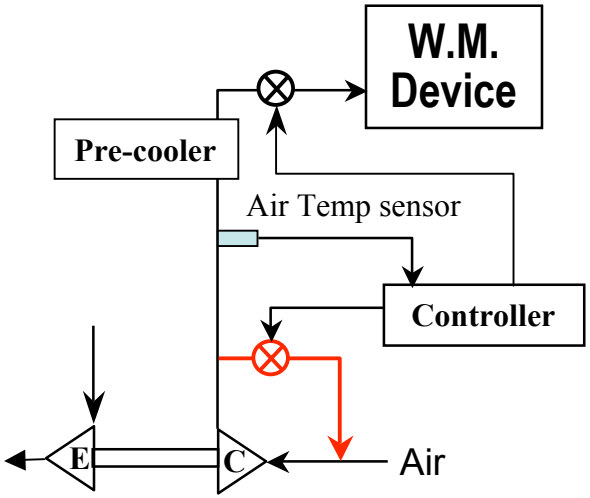
- Radiator thermal performance trade studies

Technical Accomplishments / Progress

- **Established Fuel Cell interface guidelines**
  - Peak power waste heat: 65 kW at 80 °C
  - Cathode humidification: 50% to 90% relative humidity
  - Oxygen utilization: 50% (stoichiometric ratio 2)

  (Received fuel cell stack simulation data from ANL)

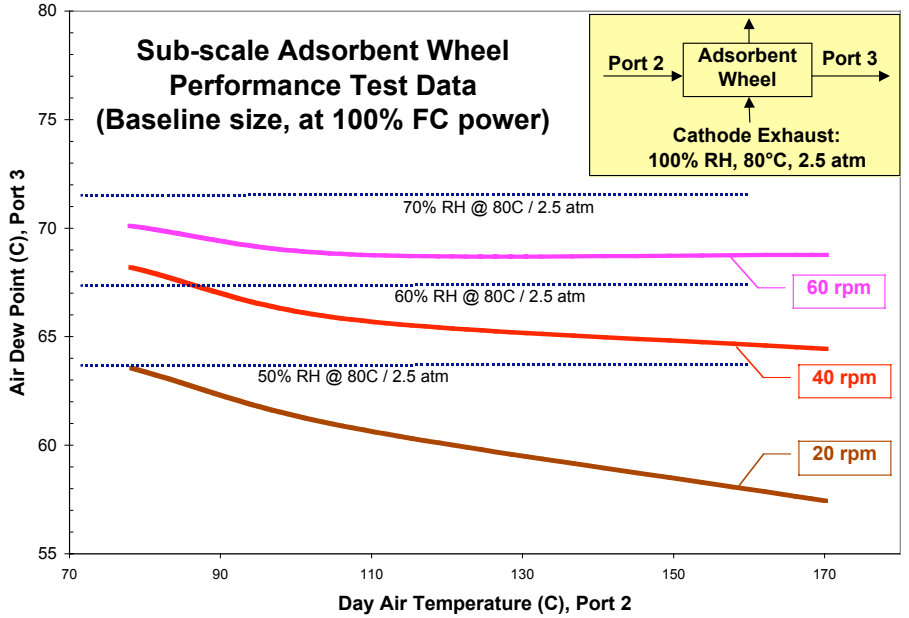
- **Obtained air compressor interface requirements**
  - Compressed air pressure: 2.5 atm at maximum power
  - Compressed air temperature:
    - Max. 170 °C at amb. 50 °C / 100% power (may need a pre-cooler)
    - Min. -5 °C at amb. -20 °C / 10% power (a potential solution: air re-circulation at compressor stage)

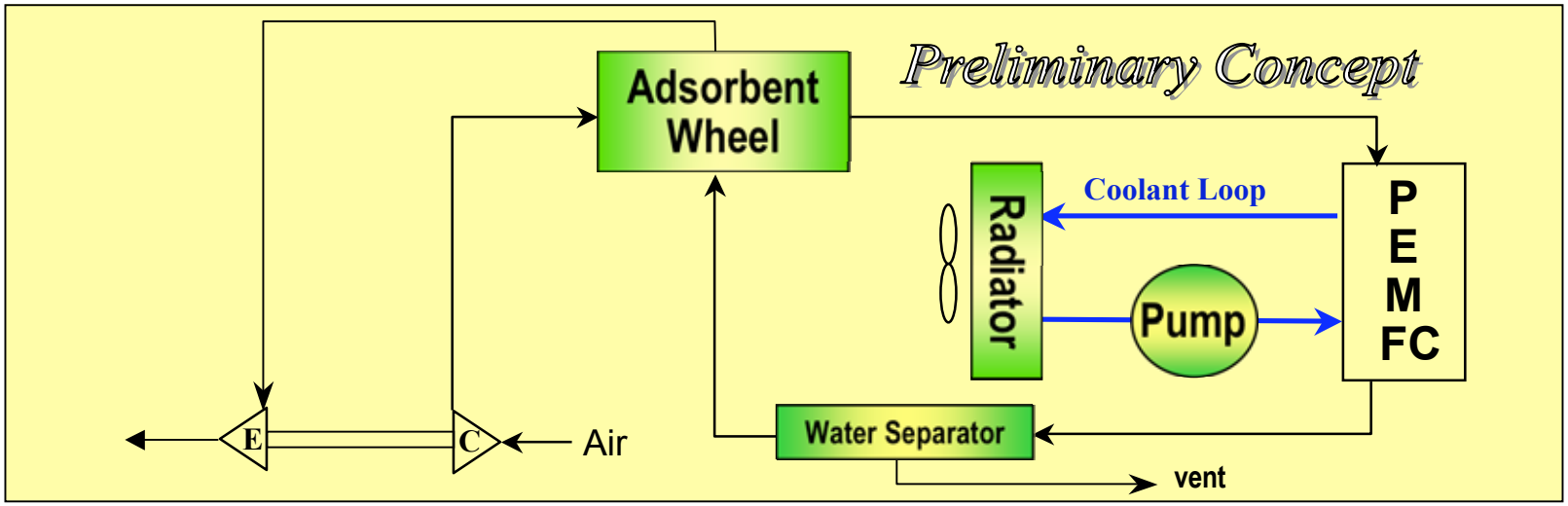


Honeywell

Technical Accomplishments / Progress

- **Adsorbent Wheel**
  - Sub-scale unit performance testing completed
    - 100% FC power
    - 50% FC Power
    - 25% FC power
  - System modeling and sizing in progress

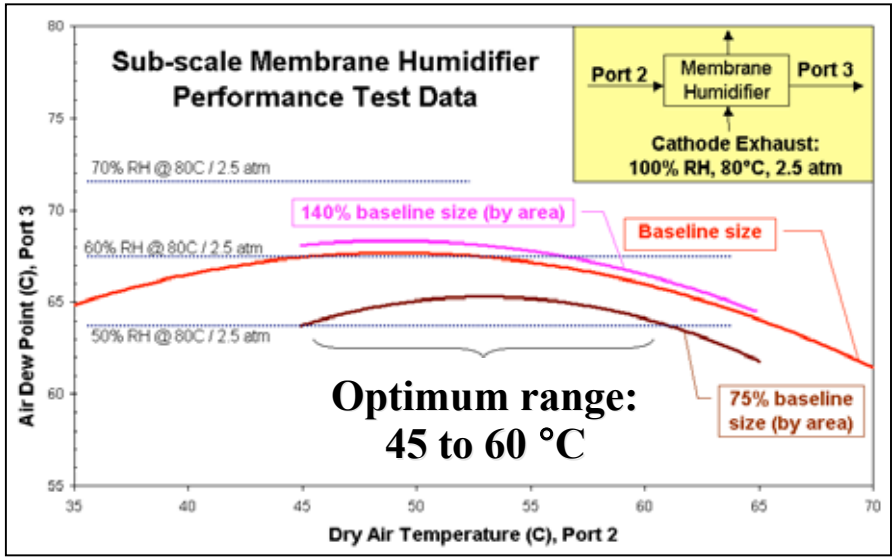


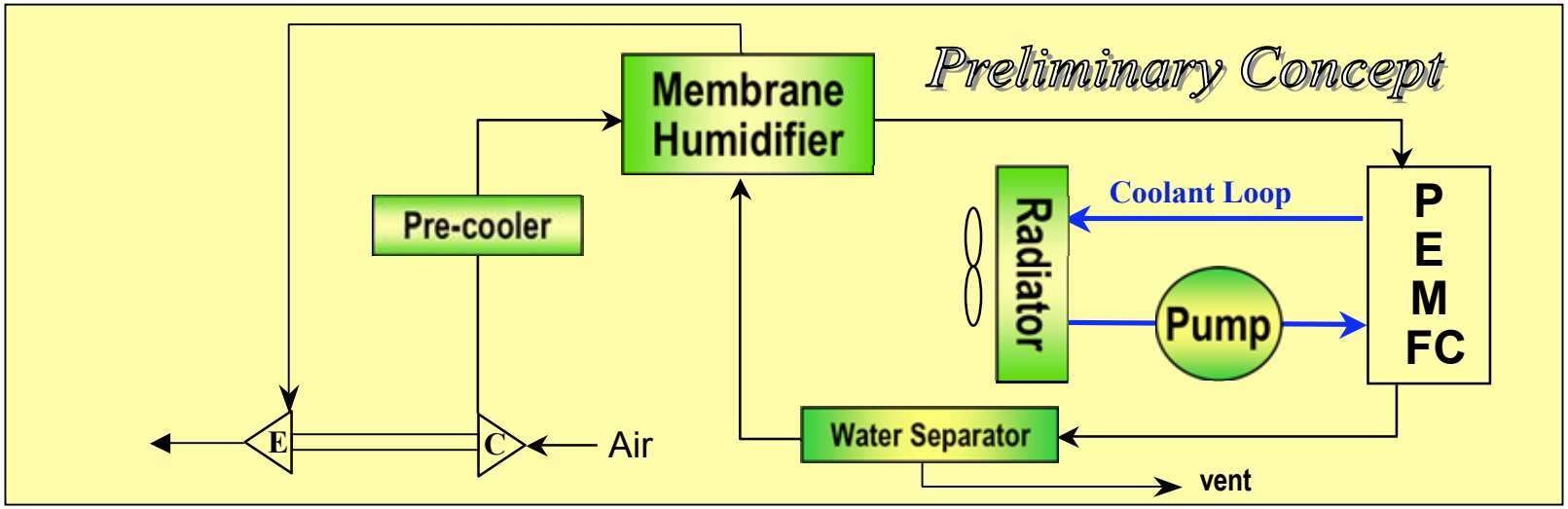


Honeywell

Technical Accomplishments / Progress

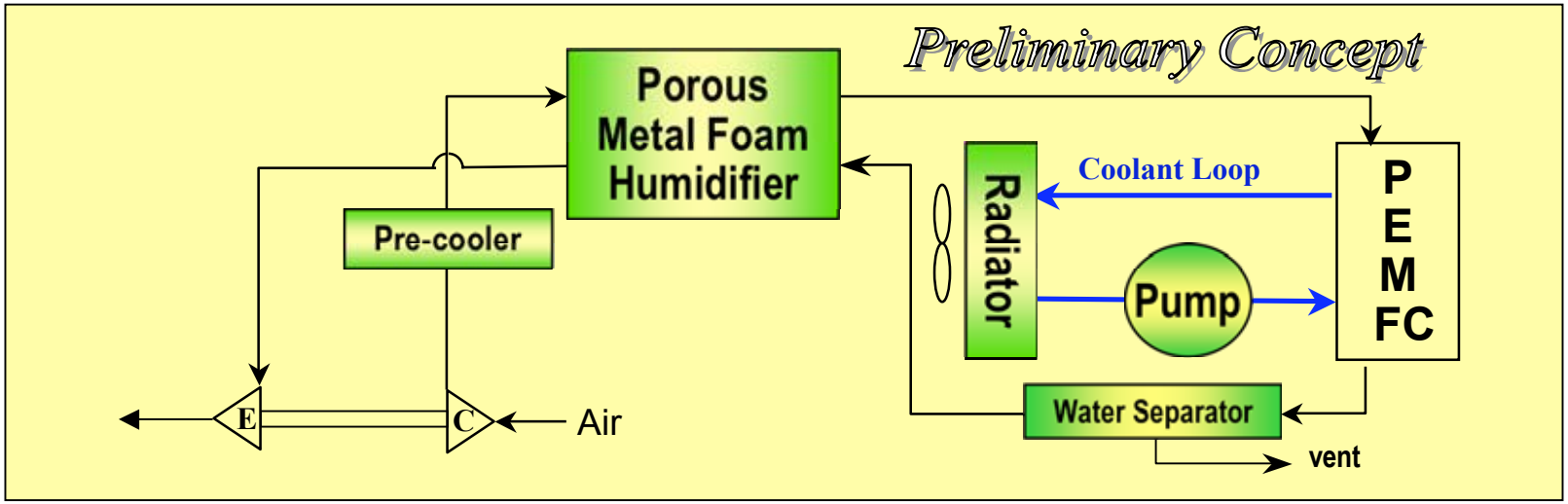
- **Membrane humidifier**
  - Sub-scale unit performance testing completed
    - 100% FC power
    - 25% FC power
  - System modeling and sizing in progress





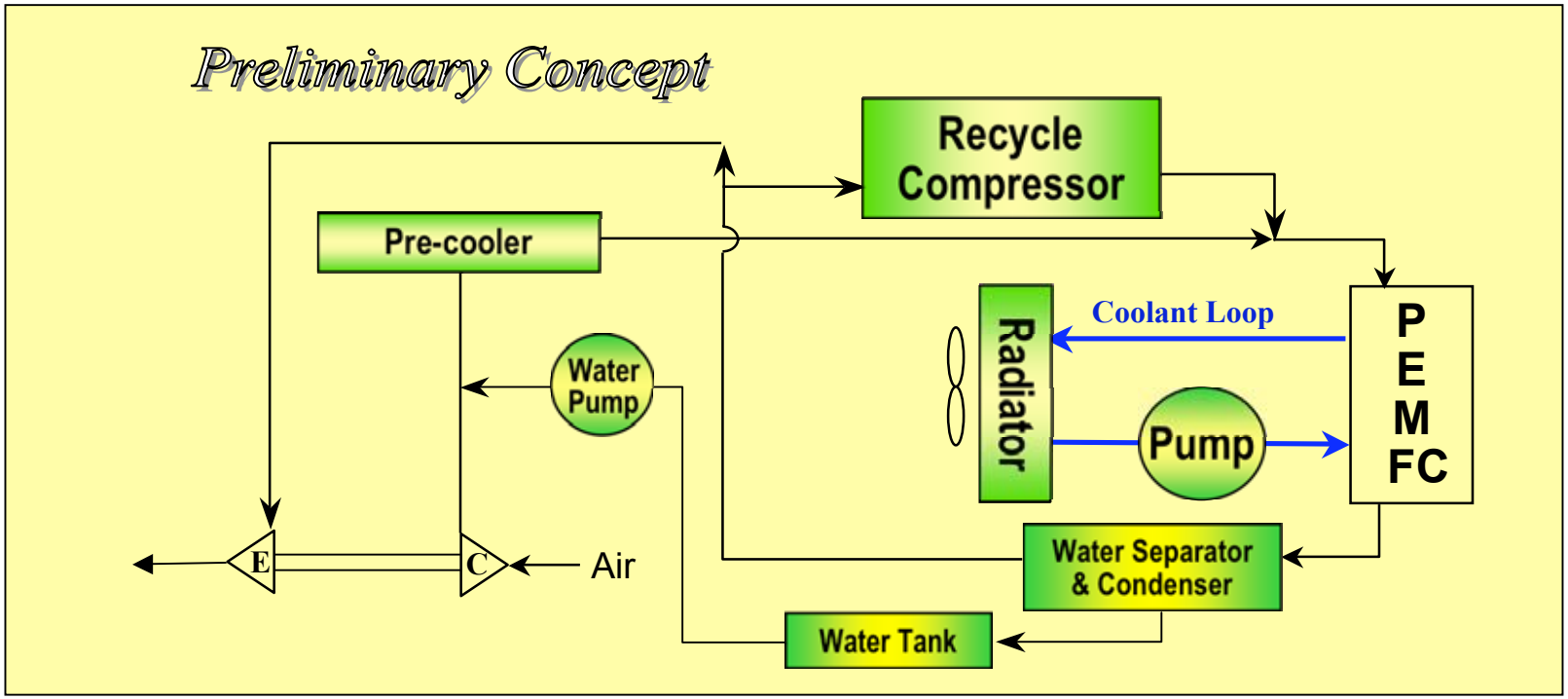
Technical Accomplishments / Progress

- **Porous Metal Foam Humidifier**
  - Evaluation tasks in progress
    - Designed and fabricated samples for material property tests
    - Tested material permeability and bubble pressure
    - Developing input/output performance model for device sizing
    - Establishing preliminary unit size with vendor
  - System modeling and sizing in progress



Technical Accomplishments / Progress

- **Cathode recycle**
  - Air humidification: cathode inlet 60% RH condition can be reached with water spray (system complexity increases)
  - Recycle fan and recycle compressor are under evaluation for power consumption comparison



Honeywell

Technical Accomplishments / Progress

- **Radiator thermal performance trade study**
  - Evaluating 3 options
    - Conventional "automotive" type tube-fin design,
    - Conventional "aerospace" type plate-fin design, and
    - Advanced microchannel type plate-fin design
  - Preliminary volume comparison with 65 kW heat load at 80 °C
    - Conventional "automotive": 100% - baseline volume
    - Conventional "aerospace": 75%
    - Advanced microchannel: 50%
  - Additional design trade studies in progress
    - Balancing power consumption, pressure drops, etc.
  - Off-the-shelf automotive designs cannot meet expectations
  - Conventional aerospace & advanced microchannel designs need
    - Suitable air side contamination control and
    - Development for low cost and mass production

Interactions and Collaborations

- **Argonne National Laboratory**
  - Romesh Kumar, Rajesh Ahluwalia: GCTool program
    - Established interface between the TWM system and PEM fuel cell stack
    - Mutual assistance in adsorbent wheel test / simulation data
- **Honeywell Turbo-compressor project**
  - Established interface between the TWM system and high pressure air management system
- **Fuel Cell Power System / Automotive OEMs**
  - Obtain/seek inputs from OEMs

Future Work

- **Remainder of FY 2004:**
  - Two design reviews:
    - Down-select the “optimum” TWM system from 4 different concepts
    - Establish TWM system and component specifications
  - Kickoff component designs
  - Start full scale “humidifier” component test bench setup

- **FY 2005:**
  - Complete component designs and procure research hardware
  - Start component testing

- **FY 2006:**
  - Complete component testing
  - Demonstrate a breadboard TWM system performance