Identification of Breakout Topics, and Initiation of Breakout Group Discussions

A. Session on MCFC-Stack AR&TD Issues

Facilitator: ***Julianne Klara*** *(FETC)*
Scribe: ***Diane Hooie*** *(FETC)*

Summary

Fourteen people were present in this session, representing manufacturers, research and development institutions, and consultants. All attendees, including the facilitator and scribe, were engineers. In addition, eight were foreign visitors.

The format of the session consisted of a brainstorming session and then the nominal group technique was used to prioritize the issues. This technique involves each participant voting for the his/her top three issues, and three points are assigned for the top issue, two points for the second, and one for the third. The votes are then tallied, with the most votes going to the issues that should have the highest priority.

Cell conversion efficiency was identified as the most important issue. This involves the reduction of polarization losses as well as improved heat removal from the cells. The second priority identified was ***separator plate materials***. Corrosion needs to be reduced as well as improved active area and wet seals needs to be developed. The third key item identified was ***improvement of the electrolyte***. This includes reduction of several key mechanisms: creep, evaporation, migration, segregation, ionic degradation, and nickel oxide solubility.

The focus of this session were those advanced research and development issues related only to the molten carbonate stack. However, in the process of developing the key issue list, other issues were identified. At the request of the participants, these were also prioritized using the same technique. The top issues include improved robustness of the stack, commercial availability of components and materials, seal integrity, and thermal cycle ability.

Discussion

Participants identified five key areas that need improvement for the fuel cell stack. They then identified specific stack issues that would improve those areas. These were further divided into advanced research and development needs or product development/improvement needs that would probably not be addressed through an AR&TD program. The stack issues were then ranked according to the highest priority. These are shown below.

Code	Advanced Research and Technology Development Issues
	Durability
‘D1	Separator plate materials - Reduce corrosion - Improve active area/wet seals
‘D2	Electrolyte (match to operating conditions) - Reduce creep - Reduce evaporation - Reduce migration (definitely not a problem for internally manifolded, externally manifolded reported it is also not a problem) - Reduce segregation (gradation of two ion species) - Reduce NiO solubility
‘D3	Lack of methodology for accelerated long-term testing
	Reliability
	No AR&TD issues identified.
	Robustness
‘R1	Negative Cells operation - Examine effect on other cells - Understand mechanism
	Cost and Performance
‘P1	Cell conversion efficiency - Reduce polarization - Improve heat removal/thermal management
‘P2	Improve volumetric density (W/ft^3)
‘P3	Improve footprint (W/ft^2)
‘P4	Develop thinner cells
	Looking Toward the Future
‘N1	Develop new and innovative ideas. Future generation.

These were ranked in the following table. Note that "thinner cells" received no votes and was not ranked.

AR&TD Issues by Priority		
Rank	*Issue*	*Total Points*
1	P1 - Cell conversion efficiency	33
2	D1 - Separator plate materials	18
3	D2 - Electrolyte (match to operating conditions)	16
4	D3 - Lack of methodology for accelerated long-term testing	6
4	P2 - Improve volumetric density (W/ft^3)	6
6	P3 - Improve footprint (W/ft^2)	6
7	N1 - Develop new and innovative ideas. Future generation.	2
8	P4 - Negative cells operation	1

Non-AR&TD Issues	
Code	
	Durability
‘D4	Seal integrity
‘D5	Reuse/recycle materials and components
‘D6	Repairableness
‘D7	Stability of reforming catalysts
‘D8	Thermal cycle ability
	Reliability
‘R2	Defect-free manufacturing repeatability
	Robustness
‘R3	Ability to operate under off-design conditions
	Cost and Performance
‘C1	Improve manufacturing processes and assembly
‘C2	Commercially available components and materials
‘C3	Design simplification
‘C4	Compact/portable system/develop other applications
	Looking Toward the Future
	Nothing included in this topic.

These were ranked in the following table. For these issues, there was little difference in most of the topic areas. However, “stability of reforming catalysts” received no votes and was not ranked.

Non-AR&TD Issues by Priority		
Rank	*Issue*	*Total Points*
1	R3 - Ability to operate under off-design conditions	10
1	C2 - Improve manufacturing processes and assembly	10
3	D8 - Thermal cycle ability	7
3	D4 - Seal integrity	7
5	D5 - Reuse/recycle materials and components	6
6	D6 - Repairability	5
6	R2 - Defect-free manufacturing repeatability	5
6	C3 - Design simplification	5
9	C1 - Improve manufacturing processes and assembly	3
10	C4 - Compact/portable system/develop other applications	2

B. Session on SOFC-Stack AR&TD Issues

Facilitator: ***Janice Murphy*** *(FETC)*
Scribe: ***William Cary Smith*** *(FETC)*

Summary

A group of manufacturers, developers, researchers, and industry personnel gathered to discuss the specific research needs for solid oxide fuel cell advanced research and technology development. The group identified 13 specific areas of interest. Each participant then voted for the two most critical issues from their viewpoint. These votes were tabulated and are shown in the following table.

Specific Needs for SOFC AR&TD

	Area	Votes Cast
1	Seals for planar in short term, and tubular in long term	4
2	Low-cost fabrication including thin films for electrolyte and interconnect	11
3	Stack development for low-temperature planar material	6
4	Interconnect issues, stability, material selection (metallic/ceramic)	3
5	Hydrocarbon operation of low-temperature fuel cells	4
6	Thin film technologies with low cost	0
7	New materials to enhance chemical capabilities	0
8	Availability needs (when will they be ready?)	0
9	Funding on development scale for planar	9
10	Balance between power density and efficiency (optimize life cycle costs; area of specific resistance)	0
11	Reliability/maintenance/endurance from utility standpoint	4
12	Thermal cycling (tubular and especially planar)	0
13	De-emphasize multi-function fuel cells (modular design for low cost)	1

Discussion

The top three categories: ***low-cost fabrication, funding, and stack development at low temperature***, were topics discussed in more detail.

There was general agreement that there needed to be more work conducted in electrolyte and interconnect fabrication emphasizing low fabrication costs.

The group would like to see DOE funding increased for intermediate temperature planar fuel cells. However, the group did not have a plan on how this might be done. Other sources of funding were not suggested. An alternative of recoupment was explored and the majority (11 to 1) of those voting favored this approach.

The third priority was the development of stacks for low temperatures in the 600 to 800 °C range. This should include system integrations of existing technology, modeling component and complete power systems, hydrocarbon operation results, and critical data base development.

C. Session on Other Fuel Cell Technologies and Applications

Facilitator: ***Daniel Rastler*** *(EPRI)*
Scribe: ***Damon Benedict*** *(FETC)*

Summary

About 13 people attended this breakout session, representing manufacturers, developers, researchers, and government. The discussion primarily related to Proton Exchange Membranes (PEMs), including PEM applications, R&D needs, and approach to meet these R&D needs. Specific suggestions included:

PEM Applications:
- Portable Power (about 200 kW)
- Small Stationary Power (2 -1,000 kW)
- Transportation
- Auxiliary Power Units (2 -60 kW)
- Emergency Applications
- Biomass, Industrial, or Rural Utilization

PEM R&D Needs:
- Fuels Logistics
- Fuel Processing
- Fuel Cell Concerns, including
  - effects of sulfur and trace organics
  - operation at higher temperatures
  - new catalysts
- Hydrogen Storage

PEM R&D Approaches:
- Define Needs and Problems
- Present the Needs and Problems to Other Disciplines (e.g., at conferences, etc.)
- Good Front-End Coordination Utilizing Consortia via the ATS Experience
- Develop Transition Plan
- Identify High-Value Market Entry

Other fuel cell applications that were discussed included utilization of biomass gas and logistic fuels, regenerative systems, and hybrid systems.

D. Fuel Cell Balance-of-Plant Session

Facilitator: ***John Wimer*** *(FETC)*
Scribe: ***Kevin Krist*** *(GRI)*

Attendees

Around 15 people attended the session, including but not limited to representatives from fuel cell and turbine manufacturers, public utilities, research organizations, architecture-engineering firms, and government agencies. An attendance list was distributed and taken up by the session organizer.

Objective: To assemble and prioritize advanced research and technology development (AR&TD) ideas for the fuel cell balance-of-plant (BOP).

Agenda: (1 hour session)

Introduction (5 minutes)
Brainstorm ideas (20 minutes)
Discuss pros and cons of each idea (20 minutes)
Prioritize ideas (10 minutes)

Brainstorming

During brainstorming, the following areas, listed in no particular order, were suggested for AR&TD work on the fuel cell BOP. It was noted that, depending on the definition of AR&TD, some of these areas may not be appropriate for AR&TD.

A. Power Conditioning
   1. cost effective inverters
   2. voltage stabilizers
   3. transformers

B. Fuel Processing
   1. reformer (with and without shift)
   2. multi-fuel capability

C. Cleanup of Fuel, Air and Water
   1. sulfur removal

D. Siting Requirements
   1. climate proofing for marine environments (salt ingestion)
   2. siting codes and standards, e.g., indoor/outdoor operation, operation in enclosed spaces

E. Controls

F. Sensors
   1. long-term (8,000 - 10,000 hours) stability of sensors and transmitters

G. Steam Turbines

H. Turbomachinery, e.g., Gas Turbines

I. Modular Packaging

J. Standardization

K. BOP Economics
   1. identify cost reduction opportunities by benchmarking BOPs of competing power technologies

L. System Integration/Modeling
   1. combinations of different fuel cells, e.g., high and low temperature cells

M. Insulation (thermal/electrical)
   1. highly effective, low cost

N. Heat Exchangers
   1. options to eliminate

O. Systems Development for New Applications and Market Studies
   1. develop BOP for small capacity FC systems
   2. mobilization, including motion sensitivity and high shock capability
   3. provisions for cogeneration
   4. potable water

P. Cost Reduction for Installation and Operation and Maintenance
   1. make the BOP user friendly

Q. Designs for Different Load Profiles, e.g., Peak, Intermediate, Base

Prioritization of AR&TD Areas for the Fuel Cell BOP

The 17 areas listed above, lettered A-Q, were prioritized using a multi-voting technique. Each attendee had three "votes" to distribute as he or she wished among the 17 areas, including assigning multiple votes to a single area. The results of the prioritization are shown in the following table.

Priority	AR&TD Area for Fuel Cell BOP	Votes Received
1	Fuel Processing	7
1	Power Conditioning	7
3	Siting Requirements	5
4	Insulation	4
4	System Integration/Modeling	4
4	Turbomachinery	4
7	Cleanup of Fuel, Air, and Water	2
7	Systems Development for New Applications and Market Studies	2
9	Cost Reduction for Installation and Operation and Maintenance	1
9	Modular Packaging	1
10	BOP Economics	0
10	Controls	0
10	Designs for Different Load Profiles	0
10	Sensors	0
10	Standardization	0
10	Steam Turbines	0