Global Assessment of Hydrogen Technologies
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TASK 6 REPORT
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Promoting a Southeast Hydrogen Consortium

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1. Introduction

The purpose of this project task was to establish a technical consortium to promote the deployment of hydrogen technologies and infrastructure in the Southeast. The goal was to partner with fuel cell manufacturers, hydrogen fuel infrastructure providers, electric utilities, energy service companies, research institutions, and user groups to improve education and awareness of hydrogen technologies in an area that is lagging behind other parts of the country in terms of vehicle and infrastructure demonstrations and deployments.

1.1 Task Scope

Proposed tasks to be performed through the consortium included the following:

1. Offer education programs to increase the knowledge of the new hydrogen technologies.

2. Increase the awareness of the new hydrogen technologies through various mechanisms; such as promotional materials for public media, web-site, and high school and college programs.

3. Organize a Hydrogen Conference in the Southeast to present ongoing work in the fields of vehicle technologies, hydrogen infrastructure, safety issues, and deployments.

4. Interact with other hydrogen programs in the U.S.

5. Conduct technology transfer programs with local community, regional, state or national agencies.

1.2 Strategic Partnership

When the University of Alabama at Birmingham (UAB) began investigating opportunities to establish a Southeast Hydrogen Consortium it soon identified a similar effort underway in Atlanta. The Center for Transportation and the Environment (CTE) and its sister organization the Southern Fuel Cell Coalition (SFCC) have goals similar to those identified in the scope for this project. Rather than duplicate efforts and possibly fragment resources, UAB decided to join forces with CTE and the SFCC to promote hydrogen technologies in the Southeast.

The Center for Transportation and the Environment is an organization whose goal is to provide resources to people or organizations committed to the idea and practice of advancing and implementing new transportation technologies. Since its start in 1993, CTE has managed a portfolio of $90 million in team research, development, and demonstration projects involving some 450 organizations in the advanced transportation

field. These projects represent a broad range of transportation-related challenges, including:

- Technology development
- Testing
  Public awareness campaigns
- Educational programs
- Marketing research
- Commuter behavior studies

CTE has facilitated funding for these projects and others from the U.S. Departments of Defense, Energy, Interior, and Transportation, as well as from the U.S. Army and NASA, among many others. Research, development, and demonstration projects have included:

- Advances in flywheel battery technology
- Chemical batteries and battery charging systems
- High performance inverters
- High-power electric traction drives
- Electromechanical suspension systems
- Fuel cell transportation technologies
- Prototype vehicles, including hybrid-electric HMMWV, an advanced propulsion system locomotive, advanced electric tow tractors and trams, and electric and hybrid-electric buses

Current membership in CTE includes the organizations listed in Table 1.1. They represent national and regional leaders in the deployment of alternative fuel vehicles. A sister organization of CTE is the Southern Fuel Cell Coalition (SFCC), the primary goal of which is to create a coalition of individuals and organizations who have a vested interest in the growth, development, and commercialization of transportation-related fuel cell technological and manufacturing capacities in the southeastern U.S. The coalition fosters greater coordination, collaboration, and information sharing among existing as well as emerging efforts in the Southeast, thereby accelerating the development, demonstration and commercial viability of this critical technology for transportation applications.

After discussions with CTE and SFCC, UAB became a member of both organizations and began working through them to promote the research carried out under this project as well as hydrogen awareness in general. The following sections detail specific hydrogen outreach activities UAB performed as part of this study.

Table 1.1 Current CTE Membership

Advanced Transportation Technology Institute (ATTI)	Innovation Drive
American Maglev Technology, Inc.	LOGANEnergy Corp.
Atlantic Station, LLC	Martin Marietta Composites, Inc.
Ballard Power Systems	Mobile Energy Solutions, LLC
Buckhead Area Transit Management Association (BATMA)	Nilar
Blue Bird Corporation	Oak Ridge National Laboratory (ORNL)
Central Atlanta Progress	SK International, Inc.
Chattanooga Area Regional Transportation Authority (CARTA)	Savannah River National Laboratory (SRNL)
Columbian Chemicals Company, Inc.	SENTECH, Inc.
EVamerica	Sevierville, Tennessee, City of
Ebus, Inc.	Southeast Energy Efficiency Alliance
Eka Chemicals, Inc.	Southern Company
Electro Energy, Inc.	Stennis Space Center (SSC)
Emory University	Test Devices, Inc.
Emprise Corporation	Texas H2 Coalition
Gas Technology Institute (GTI)	University of Alabama at Birmingham (UAB)
General Hydrogen	University of Tennessee at Chattanooga
Georgia Tech Research Institute (GTRI)	University of Tennessee at Knoxville
Hawaii Center for Advanced Transportation Technologies (HCATT)	University of Texas at Austin

2. Hydrogen Outreach Efforts

2.1 Generation FC Hydrogen Conference

The Southern Fuel Cell Coalition sponsored a conference in 2006 to highlight progress in the development and deployment of hydrogen technologies in the Southeast. The *Generation FC Conference* was held in Atlanta, Georgia on December 4-6, 2006. Among its goals were to:

- Present status reports on hydrogen demonstration projects in the Southeast;
- Discuss opportunities for future hydrogen demonstrations;
- Present results of research related to hydrogen vehicle technologies and infrastructure;
- Present promising hydrogen technologies;
- Develop partnerships for future hydrogen related projects.

With the approval of the Department of Energy, UAB became a conference co-sponsor and developed a technical session for the entire conference group devoted to the research work being performed under this project. Representatives from UAB and ANL presented results for each of the primary research tasks and engaged in question and answer sessions afterward. Copies of the conference presentations can be found at:

http://www.sfcc.tv/genfc_presentations.html

A list of all conference presentations is provided in Table 2.1. The conference was attended by 89 professionals representing the major companies and organizations leading the hydrogen deployment efforts in the Southeast. A list of conference attendees is provided in Appendix A.

2.2 Papers and Presentations

Both UAB and Argonne National Lab have developed papers and presentations related to the research conducted under this project. A list of papers, articles, and presentations is provided in Appendix B.

2.3 Graduate Student Participation

UAB attempted to involve graduate and undergraduate students in all phases of this research program. Three UAB graduate students developed Masters Theses based on their work for this program:

Dutta, Samrat P., 2005. "An Investigation on Emissions and Efficiency from Hydrogen-Blended Compressed Natural Gas"; M.S. Thesis completed Fall semester, University of Alabama at Birmingham, Birmingham, Alabama, 2005, (*graduated*).

Jasti, S.P., 2005. “Performance Evaluation of Hydrogen Vehicle Technologies”. M.S. Thesis completed at University of Alabama at Birmingham, Birmingham, Alabama, 2005, (*graduated*).

Upadhyaya, Jaimini, 2004 – “Hydrogen-Based Fuel Cell Technology for Combined Heat and Power Generation”, M.S. Thesis completed Fall semester, University of Alabama at Birmingham, Birmingham, Alabama, 2004, (*graduated*).

Additional students were involved in performing research, literature reviews, and data reduction for this study. Several students were taken to Argonne National Laboratory for training using the PSAT model and to observe vehicle testing.

2.4 High School Education

UAB provides internship opportunities for gifted high school students during the academic year. Three high school students from the International Baccalaureate School in Birmingham were given the opportunity to work on this project. Their tasks included performing literature reviews and preparing summary documents. Their work was structured to provide exposure to all aspects of the hydrogen vehicle and infrastructure development process.

2.5 Additional Outreach Efforts

UAB staff have taken advantage of many opportunities to present the research work performed under this program to new audiences. Technical presentations have been made to groups such as:

- UAB School of Engineering Advisory Board
- High School student audiences
- Non-engineering departments at UAB
- Professional societies
- Alabama Power
- Alabama Gas Company
- CTE Advisory Board

UAB will continue to take advantage of similar opportunities to promote the findings of this study and increase awareness of hydrogen vehicle technologies in the Southeast.

Table 2.1 Generation FC Conference Presentations

Assessment of Hydrogen Technologies for the Southeast (UAB Sponsored Technical Session)

Amgad Elgowainy, ***Argonne National Laboratory***
Jerry Gillette, ***Argonne National Laboratory***
Dr. Robert Peters, ***University of Alabama at Birmingham -*** Part One
Dr. Robert Peters, ***University of Alabama at Birmingham -*** Part Two
Dr. Virginia Sisiopiku, ***University of Alabama at Birmingham***

Innovation Hotspots in the South

Dr. Ronald Bailey, ***University of Tennessee at Chattanooga***
Dr. Wayne Davis, ***University of Tennessee at Knoxville***
Dr. Fouad Fouad, ***University of Alabama at Birmingham***
Dr. Tom Fuller, ***Georgia Institute of Technology***
Ardalan Vahidi, Clemson University

National/International Partnership Opportunities

Dr. Graham Hillier, ***Centre for Process Innovation, UK***
Kazumi Iino, ***JETRO Tennessee***
Sylvain Castonguay, ***Centre for Electric Vehicle Experimentation***

Pathways to Commercialization in the South

Russ Keller, ***South Carolina Research Authority***
Herb Nock, ***Worldwide Energy***
Brian Weeks, ***Gas Technology Institute***

Southern Project Examples and Progress Reports

Peter Bahouth, ***Atlantic Station***
Sam Logan, ***LoganEnergy***
Dale Hill, ***Mobile Energy Solutions***
Richard Thompson, ***University of Texas at Austin***

The Resources of the South: Hydrogen and Fuel Cells

Jennifer Gangi, ***Breakthrough Technologies Institute***
Dr. Karren More, Oak Ridge National Laboratory
Dr. Theodore Motyka, ***Savannah River National Laboratory***
Dr. Rajat Sen, ***SENTECH, Inc.***

APPENDIX A

GENERATION FC CONFERENCE ATTENDEES
December 4-6, 2006

Generation FC Conference Attendees, December 4 - 6, 2006.

First Name	Last Name	Company
Kenneth	Alfred	Ohio Fuel Cell Coalition
Peter	Bahouth	Atlantic Station
James	Bailey	University of Tennessee
Sheila	Barrie	UK Trade & Investment
Mark	Berns	Ecosutra Productions
Wu	Bi	Georgia Institute of Technology
Raymond	Boeman	National Transportation Research Center
Michael	Bradley	Georgia Department of Transportation
Lucy	Cabot-Smethurst	Cabot-Smethurst & Associates, Public Policy Consultants
Sylvain	Castonguay	CEVEQ
Rajeswari	Chandrasekaran	Student-GA Tech
Cheng	Chen	Georgia Tech
David	Cocke	Lamar University
Doyle	Cotton	SSOE, Inc.
Peter	Crofton	Toler & Hanrahan LLC
Amy	Curry	Panattoni Development Company
Albert	Curtis	EVAmerica
Edward	Danko	Savannah River National Laboratory
Wayne	Davis	University of Tennessee
Scott	Doron	Southern Technology Council
Ron	DuBose	Emprise Corporation
Tevin	Dye	JETRO Atlanta
Andy	Eklov	Ebus, Inc.
Amgad	Elgowainy	Argonne National Lab
Jeffery	Faile	Reznick Group
Bryon	Fortner	City of Sevierville
Fouad	Fouad	University of Alabama-Birmingham
Jim	Frierson	ATTI
Tom	Fuller	Georgia Institute of Technology
Kevin	Gallagher	Student - Ga Tech
Jennifer	Gangi	BTI/Fuel Cells 2000
Jerry	Gillette	Argonne National Laboratory
Grant	Godwin	Martin Marietta Composites, Inc.
Lee	Grannis	Greater New Haven Clean Cities Coalition, Inc.
Paul	Griffith	Advanced Transportation Technology Institute (ATTI)
Mark	Hairr	ATTI
Kevin	Harris	Hydrogenics Corporation
Tequila	Harris	Georgia Institute of Technology
Robert	Hay	EPB Telecommunications
Robert	Hebner	University of Texas at Austin
Steve	Hendrix	City of Sevierville
Dale	Hill	Mobile Energy Solutions
David	Hill	BJCTA
Graham	Hillier	Centre for Process Innovation
Kazumi	Iino	JETRO Tennessee
Russel	Keller	South Carolina Research Authority

First Name	Last Name	Company
Sam	Logan	Logan Energy
Lou	Magnarella	SAFT America, Inc.
Paul	Mazurek	Reznick Group
Richard	McDonald	Georgia Environmental Protection Division
Stewart	McKenzie	Columbian Chemicals
Ron	Methier	Methier and Associates
Karren	More	Oak Ridge National Laboratory
Theodoore	Motyka	SRNL
Kazuo	NAGASHIMA	NISSAN Technical Center NA
Kerry	Nelson	Balch & Bingham LLP
Herb	Nock	Worldwide Energy
Jay	Olliff	AGL Resources
Pinakin	Patel	FuelCell Energy, Inc.
Vicki	Payne	Innovation Drive, Inc.
Robert	Peters	University of Alabama-Birmingham
Lee	Peterson	Reznick Group
Eric	Ping	Student-GA Tech
Pierluigi	Pisu	Clemson University
John	Powell	EVAmerica
Charles	Pritzlaff	Georgetown University
Dan	Raudebaugh	CTE/SFCC
Eric	Register	Davis Register LLP
Takeshi	Saito	JETRO Atlanta
Randolph	Scovil	Home Planet
Rajat	Sen	Sentech, Inc
Amanda	Shailendra	Georgia Department of Economic Development
Dan	Simpson	ATTI
Virginia	Sisopiku	University of Alabama-Birmingham
Ian	Skelton	AGL Resources
Alvin	Smith	Seikoh Giken
Eric	Sonnichsen	Test Devices, Inc.
Ian	Stewart	North of England Inward Investment Agency
Andrew	Sullivan	University of Alabama at Birmingham
Ron	Sweeney	Chattanooga Area Regional Transportation Authority (CARTA)
Yvette	Taylor	Federal Transit Administration
Richard	Thompson	UT - Center for Electromechanics
Frank	Trotter	General Hydrogen Corporation
Tony	Troutt	General Hydrogen Corporation
Ardalan	Vahidi	Mechanical Eng., Clemson University
Reddy	Venumbaka	Texas State University
Cynthia	Waites	BJCTA
Brian	Weeks	Gas Technology Institute
Glen	Whitley	UK Trade & Investment
George	Wolff	Worldwide Energy, Inc.
Tony	Wu	Southern Company
Carla	York	Innovation Drive, Inc.
Dick	Ziegler	Sentech, Inc.

APPENDIX B

ARTICLES, PAPERS, AND PRESENTATIONS GENERATED UNDER THIS RESEARCH PROGRAM

Theses:

Dutta, Samrat P., 2005. "An Investigation on Emissions and Efficiency from Hydrogen-Blended Compressed Natural Gas"; M.S. Thesis completed Fall semester, University of Alabama at Birmingham, Birmingham, Alabama, 2005, (*graduated*).

Jasti, S.P., 2005. "Performance Evaluation of Hydrogen Vehicle Technologies". M.S. Thesis completed at University of Alabama at Birmingham, Birmingham, Alabama, 2005, (*graduated*).

Upadhyaya, Jaimini, 2004 – "Hydrogen-Based Fuel Cell Technology for Combined Heat and Power Generation", M.S. Thesis completed Fall semester, University of Alabama at Birmingham, Birmingham, Alabama, 2004, (*graduated*).

Publications:

Sisiopiku, V.P. , Rousseau, A., Fouad, F.H., and Peters, R.W. (2006). "Technology Evaluation of Hydrogen Light-Duty Vehicles". *ASCE Journal of Environmental Engineering*, Vol. 132, No. 6, June Issue, pp. 568-574.

Conference Proceedings:

Upadhyaya, J., R.W. Peters, F.H. Fouad, T. Das, J.F. Miller, and W.F. Podolski, 2004. "Environmental Impact of Fuel Cell Technology for Electric Power Generation: An Overview and Case Studies", Paper included in ***Proceedings of the 2004 Annual American Institute of Chemical Engineers (AIChE) Meeting***, Topic: T3 on Fuel Cells, 35 pages, Austin, Texas, (November 7–12).

Sisiopiku, V.P. , Rousseau, A, Fouad, F., and Peters, R.W. (2006). "An Assessment of Vehicular Energy Use by Hydrogen and Gasoline Powertrains for a Mid-Size Passenger Car", CD ROM Proceedings of the 85th Transportation Research Board Annual Meeting, Washington, D.C.

Sisiopiku, V.P. , and Jasti, S.P. (2005). "Performance Evaluation of Hydrogen Vehicle Technology". Proceedings of the 2005 Huntsville Simulation Conference, Huntsville, AL.

Sisiopiku, V.P., R.W. Peters, and F.H. Fouad, 2007. "Emissions Associated with Various Driving Cycles for Light-Duty Vehicles", Paper included in ***Proceedings of the Huntsville Simulation Conference 2007***, Huntsville, Alabama, October 31 – November 1).

Wallner, T., H.K. Ng, and R.W. Peters, 2007. "The Effects of Blending Hydrogen with Methane on Engine Operation, Efficiency, and Emissions", Paper No. 2007-01-0474 included in ***Proc. 2007 SAE World Congress and Exhibition***, Detroit, Michigan, (7 pages).

Dutta, S., R.W. Peters, F.H. Fouad, M.J. Duoba, and H. Ng, 2004. "Performance of a Ford F-150 Using Various Fuel Blends of Compressed Natural Gas and Hydrogen", Paper included in ***Proceedings of the 2004 Annual American Institute of Chemical Engineers (AIChE) Meeting***, Topic: T3 on Fuel Cells, 19 pages, Austin, Texas, November 7–12, 2004.

Technical Presentations:

Sisiopiku, V.P., R.W. Peters, and F.H. Fouad, 2007. "Emissions Associated with Various Driving Cycles for Light-Duty Vehicles", Paper presented at the Huntsville Simulation Conference 2007, Huntsville, Alabama, October 31 – November 1).

Peters, R.W., H. Ng, and F.H. Fouad, 2006. "Emissions from a Hydrogen Compressed Natural Gas Fueled Ford F-150", Paper presented at the 2006 Spring National American Institute of Chemical Engineers (AIChE) Meeting, Orlando, Florida, (April 24–27).

Wallner, T., H.K. Ng, and R.W. Peters, 2007. "The Effects of Blending Hydrogen with Methane on Engine Operation, Efficiency, and Emissions", Paper No. 2007-01-0474 presented at the 2007 SAE World Congress and Exhibition, Detroit, MI, (April 16).

Peters, R.W., H. Ng, and F.H. Fouad, 2006. "Emissions from Hydrogen-Compressed Natural Gas Fueled Vehicles for Several Driving Cycles", Paper presented at the Generation FC 2006 Conference, Atlanta, GA, (December 4–6).

Sisiopiku, V.P., R.W. Peters, and F.H. Fouad, 2006. "Emissions Associated with Various Driving Cycles for Light-Duty Vehicles", Paper presented at the Generation FC 2006 Conference, Atlanta, GA, (December 4–6).

Elgowainy, Amgad, M. Mintz, and J. Gilette, 2006. "Case Studies of H_2 Production and Delivery: Energy Use and GHG Emission Analysis", Paper presented at the Generation FC 2006 Conference, Atlanta, GA, (December 4–6).

Gillette, Jerry, M. Mintz, and A. Elgowainy, 2006. "Case Studies of H_2 Production and Delivery: Delivered Cost of H_2 for Alternative Markets", Paper presented at the Generation FC 2006 Conference, Atlanta, GA, (December 4–6).

Dutta, S., R.W. Peters, F.H. Fouad, M.J. Duoba, and H. Ng, 2004. "Performance of a Ford F-150 Using Various Fuel Blends of Compressed Natural Gas and Hydrogen", Paper presented in the session on "Environmental Impact of Fuel Cell Technology" at the 2004 Annual American Institute of Chemical Engineers (AIChE) Meeting, Austin, Texas, November 7–12, 2004.

Upadhyaya, J., R.W. Peters, F.H. Fouad, T. Das, J.F. Miller, and W.F. Podolski, 2004. "Environmental Impact of Fuel Cell Technology for Electric Power Generation: An Overview and Case Studies", Paper presented in the session on "Environmental Impact of Fuel Cell Technology" at the 2004 Annual American Institute of Chemical Engineers (AIChE) Meeting, Austin, Texas, November 7–12, 2004.

Upadhyaya, J., R.W. Peters, and F.H. Fouad, 2003. "Use of Fuel Cell Technology in Electric Power Generation", Paper presented at the 2003 American Institute of Chemical Engineers (AIChE) Meeting, San Francisco, CA, (November 16–21).

Poster Paper Presentations:

University of Alabama at Birmingham (F.H. Fouad, R.W. Peters, A. Sullivan, V.P. Sisiopiku, and S. Jones) and Argonne National Laboratory (D. Hillebrand, M. Mintz, H. Ng, R. Ahluwalia, and A. Rousseau), 2005. "Global Assessment of Hydrogen-Based Technologies (TVP-13)", Poster paper presented at the DOE Hydrogen Program Review Meeting, Arlington, Virginia, (May 23-26).

Dutta, S., R.W. Peters, F.H. Fouad, H. Ng, and M. Duoba, 2005. "Comparison of Blends of CNG and Hydrogen Fuels on the Basis of Emissions and Efficiency Performance Using a Ford F-150", Poster paper presented at the 2005 Spring National American Institute of Chemical Engineers (AIChE) Meeting, Atlanta, Georgia, (April 10-14); Paper presented by J.P. Perl^{+}.

University of Alabama at Birmingham (F.H. Fouad, R.W. Peters, A. Sullivan, S. Jones, and V. Sisiopiku, 2004. "Global Assessment of Hydrogen-Based Technologies", Poster paper presented at the Hydrogen, Fuel Cells, and Infrastructure Technologies Program of the U.S. Department of Energy, Philadelphia, PA, (May 24-27).

Upadhyaya, J., R.W. Peters, F.H. Fouad, R. Ahluwalia, and E. Doss, 2005. "Hydrogen-Based Fuel Cell Technology for Combined Heat and Power", Poster paper presented at the 2005 Spring National American Institute of Chemical Engineers (AIChE) Meeting, Atlanta, Georgia, (April 10-14); Paper presented by J.P. Perl^{+}.