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Moving Toward Sustainability

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The world today relies primarily on petroleum to fuel more than 800 million passenger cars, trucks, and buses. On any given day, the International Energy Agency estimates that more than 84 million barrels of oil will be consumed worldwide, and this rate of consumption is expected to grow along with increased population and expansion of the global economy. With growing demand and finite supplies of easily recoverable petroleum, the cost of fuel for transportation has increased rapidly over the last few years, and the increase in cost is likely to accelerate as demand for oil passes the "peak oil" point when the increase in demand for oil exceeds the rate at which new proven reserves are being discovered. Clearly, the world's addiction to oil is not sustainable and will result in every increasing cost unless alternative fuel sources and technologies for transportation can be developed.

But cost of fuel for transportation is not the only issue. Concern for the impact of human activity on the environment has never been higher. This is especially true with regard to concerns about global warming which has been linked to increases in greenhouse gases due to burning of fossil fuels. Public concern for the environment has resulted in both legislative and voluntary restrictions on carbon emissions in many part of the world. This trend is expected to continue.

The electric vehicle industry is stepping up to the twin challenges of increased fuel cost and environmental impact with technology that has the potential to provide sustainable transportation for all mankind. Recent innovations in fuel cells, and advanced batteries are particularly relevant to the development of electric vehicles and associated infrastructure that will be necessary to build a truly sustainable future for transportation. Fuel cells require hydrogen that can be produced from reformation of coal, natural gas or just about any form of hydrocarbon. Producing hydrogen without increasing the emission of greenhouse gases can be done if electrolysis is used in conjunction with electricity produced by wind, solar or nuclear energy. solar or wind energy. Hydrogen powered fuel cells certainly have the potential to play an important role. A recent study by the National Academies [1] provides an optimistic scenario for the future of hybrid electric and fuel cell powered vehicles as shown in Figure 1.

Driving the scenario described in Figure 1 is the assumption that the supply of easily recoverable petroleum is finite while the demand for vehicles will continue to increase with population growth and the expanding global economy. Considerable research has been focused on fuel cell vehicles and infrastructure [2] under a research program sponsored by the U.S. Department of Energy (DOE). Small fleets of hydrogen powered automobiles have been produced by General Motors [3], Ford [4], Daimler Chrysler [5], and Hyundai-Kia Motors [6] as part of this cooperative program. Other consortia members have been focused on hydrogen infrastructure, including generation, compression, storage, and dispensing [7, 8, 9, 10, 11]. Hydrogen research is also being conducted within DOE at the new fuel cell research laboratory at the Savannah River National Laboratory, Oak Ridge National Laboratory, Argonne National Laboratories [12, 13], and the National Renewable Energy Laboratory [14], and Lawrence Livermore National Laboratory [15], and Los Alamos [16]. Internationally, BMW, Toyota and Honda have all demonstrated prototype hydrogen fuel cell powered automobiles.

While the great majority of hydrogen fuel cell research to date has been focused on automobiles, some work has been done in mass transit. In a report to Congress [17], the Federal Transit Administration outlines the role that fuel cell powered buses can play in mass transit. A recent technical evaluation of fuel cell bus operations has been conducted by the National Renewable Energy Laboratory [18]. Findings indicate that new hydrogen fuel cell buses do not yet have performance metrics that exceed diesel powered buses in the areas of availability and mean time between road calls, resulting in reduced operating miles per month. As expected, miles per gallon equivalent for the hydrogen fuel cell buses exceeded conventional buses, but fuel costs and overall operating costs for the fuel cell buses were higher, ranging from one dollar to six dollars per mile for the hydrogen powered fuel cell buses compared with somewhat lower costs for

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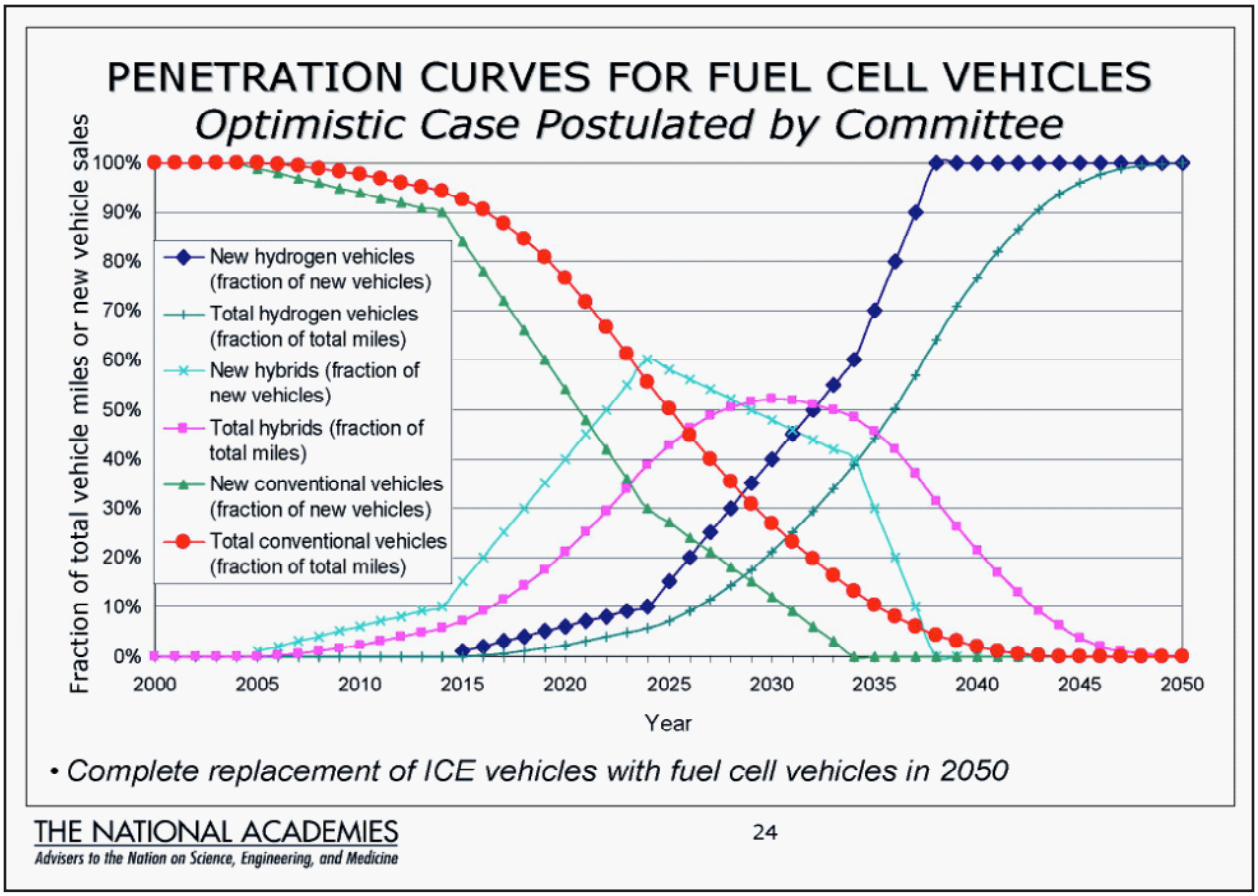

Figure 1: Market penetrations scenarios for hybrid and fuel cell powered vehicles

the conventionally powered buses. More information on performance of hydrogen powered fuel cell buses is expected in the near future from the National Fuel Cell Bus Program begun in 2006 with support from the Department of Transportation. It is too early to expect reports on the outcomes of these studies, but it can be anticipated that many of the technical and operational challenges will be addressed by this program. While the potential for fuel cell powered vehicles remains very positive, much work remains to be done. This issue of the Journal includes papers on this fuel cells, use of wind energy to produce hydrogen, and tolls that are needed to promote maximum and appropriate use of electric vehicles as part of the solutions needed to provide a truly sustainable future for transportation.

REFERENCES

[1] Committee on Alternatives & Strategies for Future Hydrogen Production and Use, Michael Ramage, Chair. The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs. The National Academies, Washington, DC. http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/nrc_presentation.pdf.

[2] Department of Energy, 2007 Annual Merit Review Proceedings, May 15-18, 2007, Arlington, VA. http://www.hydrogen.energy.gov/annual_review07_proceedings.html

[3] Rosalind B. Sell, General Motors Corporation. 2007 DOE Hydrogen Project Review. May 15-18, 2007, Arlington, VA.

[4] Ford Motor Company. Hydrogen Fuel Cell Vehicle & Infrastructure Demonstration Program Review. May 15-18, 2007, Arlington, VA.

[5] Klaus Bonhoff, DaimlerChrysler. Hydrogen to the Highways. May 15-18, 2007, Arlington, VA.

[6] Puneet Verma and Dan Casey, Chevron Hydrogen. Controlled Hydrogen Fleet and Infrastructure Demonstration and Validatino Project. May 15-18, 2007, Arlington, VA.

[7] Susanta K. Das and K. Joel Berry, Kettering University. Kettering University Fuel Cell Project. May 15, 2007, Arlington, VA.

[8] Orest Adrianowycz, GrafTech International Ltd.

ISSN 2032-6653

Next Generation Bipolar Plates for Automotive Fuel Cells. May 15-18, 2007, Arlington, VA.
[9] Steven Lasher, Jayanti Sinha, Yong Yang, and Surest Sriramulu. TIAX. Direct Hydrogen PEMFC Manufacturing Cost Estimation for Automotive Applications. May 17, 2007, Arlington, VA.
[10] Brian D. James and Jeffrey A. Kalinoski. Directed Technologies, Inc. Mass Production Cost Estimation for Direct H2 PEM Fuel Cell System for Automotive Applications. May 18, 2007. Arlington, VA.
[11] Mike Perry, Tim Patterson, and Jonathan O'Neill. United Technologies Corporation. PEM Fuel Cell Freeze Durability and Cold Start Project. May 15, 2007, Arlington, VA.
[12] R.K. Ahluwalia, X. Wang and R. Kumar. Argonne National Laboratory. Fuel Cell Systems Analysis. May 15, 2007. Arlington, VA.
[13] I. Bloom, J. Basco, L. Walker, and P. Prezas, Argonne National Laboratory. Fuel Cell Testing at Argonne Fuel Cell Test Facility. May, 2007. Arlington, VA.
[14] Keith Wipke. National Renewable Energy Laboratory. Controlled Hydrogen Fleet and Infrastructure Analysis. May 17, 2007. Arlington, VA.
[15] Salvador Aceves, Gene Berry, Francisco Espinosa, Tim Ross and Andrew Weisberg. Lawrence Livermore National Laboratory. Cryogenic Capable Pressure Vessels for Vehicular Hydrogen Storage. May 18, 2007.
[16] Tommy Rockward. Los Alamos National Laboratory. Component Benchmarking, USFCC Durability Protocols and Technically-assisted Industrial and University Partners. May 2007. Arlington, VA.
[17] United States Department of Transportation, Federal Transit Administration. Alternative Fuels Study: A Report to Congress on Policy Options for Increasing the Use of Alternative Fuels in Transit Vehicles. December, 2006. Washington DC.
[18] Leslie Eudy. National Renewable Energy Laboratory. Technology Validation: Fuel Cell Bus Evaluations. May 18, 2007. Arlington, VA.

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Dr. J. Ronald Bailey serves as the current Editor-In-Chief of the World Electric Vehicle Journal. He holds the position of Guerry Professor of Engineering and Director of the Center for Energy, Transportation and the Environment in the College of Engineering and Computer where he served as Dean of the College for three years. Immediately prior to joining UT Chattanooga, Dr. Bailey served four years as F.W. Olin Professor and Dean of the College of Engineering at Florida Institute of Technology. Dr. Bailey also served as a member of the faculty at NC State University for ten years where he taught and served as principal investigator for several research projects. At the University of Texas at Arlington, Dr. Bailey served as Head of the Mechanical & Aerospace Engineering, Dean of the College of Engineering and Vice President for four years. Dr. Bailey's experience in the private sector is highlighted by his twelve years with IBM Corporation where he held a number of engineering and management positions, each with increasing responsibility, culminating in the position of product manager for the Industrial Sector Division's Boca Raton Development Laboratory. Dr. Bailey earned Bachelor's and Master's degrees in engineering from North Carolina State University and a PhD from the Institute for Sound and Vibration Research at the University of Southampton, England.