Fuel Cell Vehicles:
Technology, Market, and Policy Issues

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Extended Abstract

This new Research Report from SAE takes a comprehensive look at fuel cell vehicles, a leading candidate for next-generation automotive design. While highlighting the rapid progress in R&D and the technology's promise for the future, this study also presents a reasoned view of the challenges to be confronted before a business case for fuel cell vehicles can be made. In addition to an in-depth examination of technical progress and the barriers remaining, a unique feature of the report is its evaluation of fuel cells within the broader context of automotive market trends, competing technologies, and policy drivers as they stand at the turn of the century.

Fuel cells are receiving growing attention as a highly efficient, low-pollution option for many energy-using systems. For motor vehicles, polymer electrolyte membrane (PEM) fuel cells promise to address multiple concerns, including air pollution, oil dependence, and global warming, while efficiently meeting customer needs for greater on-board electricity. Rapid research progress has resulted in hydrogen stacks suitable for mass production. Several automakers have pledged the introduction of fuel cell vehicles, including buses, by 2003–2005.

It is steady progress in the development of hydrogen fuel cell stacks that has moved the technology toward commercial promise. Nevertheless, time is still needed to prove out low-cost, easy-to-manufacture designs and ancillary systems. It will take several production cycles at low-to-medium volumes to gain experience, establish reliability, and achieve maturity. Over the next decade, automakers may be unwilling to commit to extensive production, since early designs could become obsolete before costs are fully recovered.

A complex set of questions pertains to the choice of fuel for fuel cell vehicles. Direct hydrogen systems offer the best environmental performance, but fundamental technical barriers must be overcome to demonstrate fully workable onboard storage systems. Moreover, it will take many years to establish a hydrogen refueling infrastructure.

Fuel storage is straightforward for liquids such as gasoline, methanol, or ethanol. Their infrastructure barriers range from nil or mild (for gasoline) to substantial (for alcohols). However, onboard processors for reforming liquids into hydrogen for stack input have not yet been demonstrated as fully workable. Moreover, such systems would increase cost and decrease environmental performance.

Additional time and experience are needed to reduce the costs of electric motors, controllers, high-power batteries, and related systems. The costs of these common components of any electrodrive vehicle add to the costs of fuel cell systems even when counting the savings from a conventional powertrain. Optimistic learning rates suggest a decade or longer time before electrodrive component costs fall to acceptable levels. Thus, fuel cell powertrains may become widely affordable no sooner than changes in fuel infrastructure become widely feasible.

Fuel cell vehicle commercialization strategies must confront the realities of competing technologies as well as real-world market forces and public policies. Advances in gasoline vehicle emissions controls make air quality alone an insufficient reason to abandon internal combustion engines over the next two decades. Urban bus applications hold more promise, since difficult-to-clean-up diesel engines, high population exposures, and central fueling abilities give fuel cells an advantage.

For cars and light trucks, market forces do not provide a strong enough call for higher efficiency to motivate even modest technology im-

provements, let alone radical technology change. Pressure will grow to address global warming and petroleum security concerns. Nevertheless, improved conventional and hybrid-electric vehicles will offer lower-cost, lower-risk ways to stretch fuel economy while meeting growing needs for onboard electricity.

Presently, U.S. transportation energy policies are doing little to advance true commercialization of advanced, high-efficiency, low-pollution vehicles. Alternative fuels policies, including fleet mandates, tax and regulatory credits, and various "fuel-neutral" strategies, have not initiated significant market transformation to date. Fuel taxation policies sustain some niche applications and a highly subsidized but limited market for ethanol blends, but fail to motivate real change.

Aggressive measures, such as California's zero-emissions vehicle mandate, have stimulated R&D. But they may not trigger investments beyond low-volume production because the broader business case for ZEV technologies remains weak. Government-industry research programs have also advanced R&D. But the absence of compelling policies for higher fuel economy inhibits extensive production investments in any technology oriented to improving vehicle efficiency, including fuel cells.

In summary, fuel cells do hold enormous long-run potential for highway vehicles. Nevertheless, evaluating the technology's current status and critical commercialization issues suggests a "deployability gap" of 10–15 years before a business case can be made for mass-market automotive applications. The juxtaposition of this long timetable for market success with automakers' significant fuel cell R&D investments presents a conundrum that this study has failed to resolve.

Closing the deployability gap will require accelerating the convergence of three key pathways, each of which involves time lags: (1) engineering development and maturation of stacks and ancillaries; (2) cost reduction for common components of electrodrive; and (3) resolution of the technical and infrastructure barriers related to the right fuel for fuel cell vehicles.

Moreover, it will take either a coordinated commitment by the auto and oil industries or major changes in public policy (or both) to break out of the box of weak market drivers and feeble transportation energy policies that may otherwise keep fuel cell technology in a largely R&D status for years to come.

Over the next 10–15 years, fuel cell vehicle demonstrations will take place and limited applications may be pursued (as for fuel cell buses). However, neither profitability nor significant impacts on petroleum consumption and greenhouse gas emissions seem likely. Thus, other technologies will be needed to address transportation energy problems over the next two decades. Nevertheless, while the R&D portfolio should be hedged with work on low-carbon fuel options for other powertrains, steady efforts on automotive fuel cells are clearly warranted in light of their long-term promise.

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Fuel Cell Vehicles: Technology, Market, and Policy Issues provides a comprehensive, up-to-date, and provocative look at what promises to be the most exiting automotive technology for the next generation. With 35 tables, 44 figures and photos, a glossary, and an extensive 230-entry bibliography, this book is a must-have reference for researchers, policy makers, investors, and anyone seeking in-depth knowledge of future transportation energy technology.

Fuel Cell Vehicles: Technology, Market, and Policy Issues (SAE Research Report RR-010, November 2001) is available from SAE Publications, 1-877-606-7323, or order via the web at www.sae.org.