ELSEVIER

Journal of Power Sources 86 (2000) 57–60

JOURNAL OF POWER SOURCES

www.elsevier.com/locate/jpowsour

The California fuel cell partnership: an avenue to clean air

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Accepted 26 October 1999

Abstract

The California Fuel Cell Partnership presently consists of eight private companies, two state agencies and a federal government representative that will attempt to demonstrate the feasibility of fuel cell cars and buses. California has attempted to advance the commercialization of zero-emission vehicles for much of the past decade to help the state reduce its high levels of air pollution. A special advisory panel convened by the California Air Resources Board concluded last year that fuel cell technology could meet the key requirements for automobiles. The successful commercialization of fuel cell vehicles would help to reduce the levels of ozone, fine particles and toxic air contaminants that pose health risks to California's population. This technology can also help to reduce carbon dioxide emissions. California regulations now encourage the development of zero and near-zero emission vehicle technologies, including fuel cells. The Fuel Cell Partnership will operate approximately 50 fuel cell cars and buses until the year 2003 in order to produce important information on the vehicles and fueling infrastructure needed to support them.

Keywords: Fuel cell; CARB; Zero-emission vehicle; Hydrogen; Methanol

1. Introduction

On April 20, 1999, several hundred journalists, environmentalists, government regulators and leaders of the automotive and petroleum industries gathered on the steps of the California State Capitol in Sacramento to hear Governor Gray Davis announce a major new endeavour to revolutionize transport in the State. To mark the occasion, two fuel cell-powered cars produced by DaimlerChrysler and Ford Motor Company drove up in virtual silence to the dais where Governor Davis discussed the formation of the California Fuel Cell Partnership. The key objective of the Partnership, Governor Davis said, is to demonstrate the feasibility of making zero-emission fuel cell vehicles available to ordinary Californians who suffer the burden of the state's notorious air pollution.

The California Fuel Cell Partnership presently consists of eight private companies, two California State agencies and the federal Department of Energy. These entities are: DaimlerChrysler and Ford, both of whom are committed to commercializing fuel cell vehicles by 2004; Honda and Volkswagen Ballard Power Systems of Vancouver Canada, one of the world's leaders in the development of fuel cell technologies; ARCO Products, Shell, and Texaco, who are major refiners and retailers of gasoline in California; and the California Air Resources Board (CARB) and the California Energy Commission (CEC). Other organizations may join in the next 6 months. The partnership is planned to operate until at least 2003. Its objectives are to demonstrate the viability of fuel cell vehicles and fueling infrastructure in California to identify and overcome barriers to commercialization of fuel cell vehicles and to increase public awareness of the technology.

The formation of the fuel cell partnership is the outgrowth of a chain of events that began in 1990, when the CARB required major vehicle manufacturers to begin the process of developing and commercializing zero-emission vehicles for use in the State. For most of the decade, attention focused almost exclusively on battery-powered electric vehicles. Recent technological advances now make it appear that electric vehicles powered by fuel cells can compete in the marketplace with battery-powered vehicles and even conventional gasoline-powered vehicles. CARB's regulations have been amended to fully recognize the

0378-7753/00/$ - see front matter
PII: S0378-7753(99)00457-7

prospect of several different kinds of advanced technology vehicles, including fuel cell vehicles, to reduce toxic and ozone-forming emissions.

A brief overview of the California Fuel Cell Partnership, is provided here, its goals and objectives, and its role in California's efforts to rid itself of unhealthy air pollution.

2. The rationale for zero-emission vehicles and fuel cell vehicles

California has long been a world leader in advancing the use of low-polluting vehicle technologies. In 1975, CARB became the first agency in the world to rely on the catalytic converter to reduce emissions from light-duty vehicles. Despite the successful introduction of the catalyst and other clean-vehicle technologies, it had become evident by the late 1980s that further technological breakthroughs would be needed to reduce air pollution to levels required by federal law. CARB determined that healthful air quality could not be achieved in the Greater Los Angeles region even with the universal use of the cleanest gasoline-burning vehicles envisioned at that time. [1] The unveiling, in early 1990, of the Impact electric vehicle prototype by General Motors convinced CARB to require major vehicle manufacturers to introduce Zero-Emission Vehicles (ZEVs) in California before the end of the decade. CARB projected that the added emission reductions from the widespread use of ZEVs would help enable California to ultimately meet its air-quality goals. It should be noted that ZEVs, unlike internal-combustion engines, do not deteriorate and become more polluting with time. Also, depending on the source of electricity or fuel used to power ZEVs, these vehicles may offer additional emission benefits over conventional vehicles because of the considerable emissions associated with the production and distribution of gasoline.

In 1996, CARB pushed back the required introduction of ZEVs to 2003 in order to give vehicle manufacturers additional time to develop advanced batteries for electric vehicles. By this time, fuel cell development had already begun to accelerate rapidly. In 1997, Daimler-Benz and Ballard Power Systems formed a partnership aimed at commercializing fuel cell vehicles by 2004. Ford joined the partnership within a short time. The rapid pace of events raised questions as to whether fuel cells could be considered a feasible ZEV technology along with battery-powered vehicles.

In 1998, CARB commissioned a panel of four respected experts to assess the state of fuel-cell development. The panel travelled throughout the world to interview developers of fuel cell technology. The panel concluded that fuel cell stack technology now meets the key requirements for automotive propulsion. Other panel findings were that methanol, gasoline or petroleum distillates are the most likely fuel in the near-term, and that a key technical challenge is the integration of fuel processors, stacks and auxiliary components into a functioning fuel cell engine. The greatest overall challenge, the panel said, is meeting stringent cost targets and developing mass-production methods.

Also in 1998, CARB amended its regulations to allow manufacturers to meet part of their ZEV requirement with vehicles producing ''near-zero'' emissions, such as hybrid electric vehicles and fuel cell vehicles powered by on-board methanol, ethanol or gasoline. These regulations provide manufacturers with an incentive to develop promising, near-zero emission technologies.

A common interest in fuel cells brought members of the California Fuel Cell Partnership together in early 1999. CARB certainly shares the enthusiasm of DaimlerChrysler, Ford Honda, Volkswagen and Ballard for the commercialization of fuel cells. The CEC recognizes that the use of fuel cell vehicles could also encourage fuel diversity, which is an important goal for the state. The participation of ARCO, Shell and Texaco is particularly welcome because these companies are especially well suited to address the fueling and fueling infrastructure needs of fuel-cell vehicles. These companies recognize that hydrogen, methanol, ethanol and other possible fuels represent an important prospective market. Associate fuel provider members, Air Products and Chemicals, Inc., Praxair and Linde A.G. share the same optimism about hydrogen.

3. Air quality trends in California

California has experienced considerable success in improving air quality while accommodating population and economic growth. Between 1980 and 1997, peak ozone levels decreased by 49% while the state's population increased by 39% and vehicle use increased by 78%. In 1999, California air quality has been better in some respects than at any time since air-quality recordkeeping began. At the time of the Grove Fuel Cell Symposium in September, the Greater Los Angeles region had not experienced a single smog alert [2] in all of 1999, the first time this has occurred. The development of cleaner motor vehicles is a leading factor for the improvement in air quality.

[1] The cleanest ICE vehicle envisioned by CARB in 1990 was the Ultra-Low Emission Vehicle (ULEV), which emits 0.04 g/mile of hydrocarbons. It was widely believed in 1990 that an ICE could only meet such a standard with the use of alternative fuels. In fact, gasoline-burning ULEVs have been available in California for the past 2 years and at least one super ultra low emitting vehicle (SULEV) has been certified for sale.

[2] A first-stage smog alert is declared when ozone levels at a particular monitoring site reach 0.20 parts per million (ppm) for a 1-h period. The National Ambient Air Quality Standard for ozone established by the U.S. Environmental Protection Agency is 0.12 ppm for a 1-h period. California's ambient standard for ozone is 0.08 ppm over an 8-h period.

The average new California light-duty motor vehicle in 1999 emits only 0.113 g/mile of hydrocarbons, more than 78% less than a new car in 1980.

Despite this impressive progress, California continues to have the worst overall air pollution in the United States. The State's hot, sunny weather, mountainous topography and automobile-dependent transport systems form the perfect combination for the trapping of hydrocarbons and nitrogen oxides over urban areas and their conversion to ozone. California's ozone levels are among the highest in the United States, and the Los Angeles region is not expected to attain healthful air quality until after 2010, the last region of the United States to do so.

Research is revealing more about the health effects of air pollution. For example, an ongoing 10-year CARB study of children in Southern California has found that children growing up in highly polluted areas have diminished lung function and are more susceptible to certain respiratory ailments. CARB is also focusing greater attention on risks posed by toxic air contaminants. Health assessments of the Los Angeles region estimate that ambient levels of two common motor vehicle pollutants, benzene and 1,3-butadiene, could account for more than 100 cancer cases per 1 million people over a human lifetime. This is more than double the risk of other industrial and vehicular pollutants such as chromium-VI, formaldehyde and perchloroethylene. Even the benzene and 1,3-butadiene risks pale next to the risk posed by diesel particulates, which is estimated at more than 800 cancer cases per 1 million people in Los Angeles. CARB in 1998 declared diesel particles to be a toxic air contaminant and is currently analyzing the need for further diesel regulations to reduce health risks. Fuel cell technology may play an important role in mitigating diesel-related risks, because fuel cells are considered a promising technology for urban transit buses and heavy off road sources, such as locomotives and marine vessels, which currently operate primarily on diesel fuel.

CARB does not actively regulate greenhouse-gas emissions; the U.S. Environmental Protection Agency sets policy in this area for the United States. However, CARB certainly recognizes the reduction in carbon dioxide emissions that would result from the successful commercialization of fuel cell vehicles and views this as an additional reason for supporting the California Fuel Cell Partnership.

4. California's low emission vehicle requirements

CARB's emission standards for light-duty motor vehicles are the cleanest in the world. A phase-in of steadily cleaner emission standards for conventional vehicles began in 1994 and will continue through 2010 and beyond. In addition, the requirement for the marketing of pure ZEVs and near-ZEVs begins in 2003. At that time, any manufacturer marketing 3000 or more light-duty vehicles in California must comply with one of the following:

- 10% of the new vehicles produced for sale or lease in California must be pure ZEVs. Battery-powered electric vehicles and fuel cell vehicles powered by on-board hydrogen would qualify as pure ZEVs.
- As an alternative, a manufacturer can receive ''partial ZEV credits'' for vehicles with near-zero emission levels comparable to the power-plant emissions associated with charging batteries for an electric vehicle. In any event, a minimum of 4% of new vehicles produced by a manufacturer must be pure ZEVs. A manufacturer can then use partial ZEV credits to comply with the remainder of the requirement.

While CARB does not favor any one ZEV or near-ZEV technology over any other, CARB continues to view the pure ZEV as the ''gold standard'' for motor vehicles, in large part because of the certainty that there will be no polluting tailpipe emissions regardless of the age or condition of the vehicle. Nevertheless, CARB created the partial ZEV credit in 1998 specifically to encourage the development of near-zero emission technologies that can provide substantial air-quality benefits. The partial ZEV credit awarded to any particular vehicle technology will vary according to the vehicle's range using electric power, and the vehicle's overall emission levels. For example, an internal-combustion engine meeting CARB's ''Super Ultra-Low Emission Vehicle'' standard (0.01 g/mile for hydrocarbons and 0.02 g/mile for nitrogen oxides) could receive credit for 0.2 of a ZEV; in other words, a manufacturer would have to market five of those vehicles to receive credit for one pure ZEV. An advanced vehicle running on compressed natural gas could receive 0.4 of a ZEV credit, and an electric–gasoline hybrid vehicle with a 20-mile electric range could receive 0.6 of a ZEV credit. A fuel cell vehicle with a methanol reformer could receive 0.7 of a ZEV credit, due to the hydrocarbon emissions associated with the reforming of methanol. An on-board hydrogen fuel cell vehicle or a direct methanol fuel cell vehicle would receive one ZEV credit and would therefore be considered a pure ZEV, as would an electric–clean fuel hybrid vehicle with a 100-mile electric range.

5. Demonstration of fuel cell vehicles

The commercialization of fuel cell vehicles would provide vehicle manufacturers with valuable options for complying with CARB's ZEV requirement. Of course, this reflects the fact that fuel cell vehicles can play a major role in reducing emissions and improving California's air quality. Before this can occur, the fuel cell vehicle prototypes that have been seen on the streets of Sacramento and other cities must be fully developed into production models that can compete effectively in the marketplace. The intent of the California Fuel Cell Partnership is to help enable fuel-cell vehicles to make that transition.

The partnership is scheduled to operate a demonstration fleet of 10 passenger cars and as many as five buses in California in 2000 and 2001. The demonstration fleet will increase to 30 passenger cars and 10 buses in 2002 and 2003. Some of those vehicles will use on-board hydrogen, while some of the passenger cars may use methanol and other fuels. All buses will be used by transit agencies and will provide regular service to the public. The cars will be operated primarily by the vehicle manufacturers, although some vehicles could be made available to fleet customers in 2003.

This demonstration project will provide invaluable information on the operation of fuel cell vehicles under real-world conditions. It will also produce important information needed for the development of fuel specifications and fueling infrastructure that would be needed to serve growing numbers of fuel cell vehicles. In addition, the demonstration will also produce information needed to support fuel cell vehicles, such as training for emergency-response providers, the development of codes and standards, and consumer research. In addition, the importance of raising the public profile of fuel cell vehicles should not be overlooked. A positive demonstration project would be likely to increase the level of interest among California car buyers in fuel cell vehicles. By proving that fuel cell vehicles offer range and convenience of refueling that are comparable to conventional vehicles, the demonstration could provide immense benefits in making Californians more comfortable with fuel cell technology.

6. Conclusion

Fuel cells represent an important new technology that could help California attain its air-quality goals while satisfying the needs of motorists. The California Fuel Cell Partnership will build upon the rapid advances in fuel cell technology as well as earlier decisions by CARB to push the development of ZEVs. The next 5 years will be a crucial and exciting time as vehicle manufacturers and fuel cell developers attempt to challenge the internal-combustion engine’s 100-year domination of the motor-vehicle market.