United States
Environmental Protection
Agency

National Risk Management
Research Laboratory
Research Triangle Park, NC 27711

Research and Development

EPA/600/SR-98/039 May 1998

EPA

Project Summary

Fuel Cell Bus Demonstration in Mexico City

Tom Gilchrist

The report discusses the performance of a full-size, zero-emission, Proton Exchange Membrane (PEM) fuel-cell-powered transit bus in the atmospheric environment of Mexico City. To address the air quality problems caused by vehicle emissions in Mexico City, a seminar on clean vehicles was held in the Mexico City area in June 1997. This seminar addressed the state of the art of several clean vehicle technologies, including the PEM fuel-cell-powered bus demonstrated by Ballard Power Systems.

This Project Summary was developed by EPA's National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Among the most serious problems facing the modern world is air pollution. In the Mexico City Metropolitan Area (MCMA), addressing this problem has become a high priority because it affects both the quality of life of its more than 15 million inhabitants, and its environment. More than half of Mexico's industry is located within the 2590 km^2 (400 mi^2) MCMA, with more than 20% of the Nation's population residing in the city itself, consuming 150 times the national average for energy per unit area, and driving 60% of the Nation's automobiles. Mexico City experiences nearly 30 million person-trips per day, generates 16,000 tonnes (18,000 tons) of garbage per day, and consumes water at a rate of more than 60 m^3 (15,850 gal.) per second.

Mexico City lies in a basin at a latitude of 19°N, and at an elevation of 2240 m (7400 ft). It is nearly surrounded by mountains that rise an additional 1200 m (4000 ft), that create a barrier to air circulation and isolate the area from the winds of regional weather patterns. For this reason, geography is an important contributor to the phenomenon of temperature inversion in which a cap of warm air sits over cooler air, trapping air polluting emissions.

Air pollution in Mexico City has increased along with the growth of the city, the movement of its population, and the growth of employment created by industry. The population of the Mexico City area is growing fast. From 1970 to 1980, the MCMA grew at a rate of 4.3% with a corresponding 9.6% growth rate for the surrounding urban municipalities. The MCMA population is expected to grow at a 1.4% annual rate and total more than 20 million people by the year 2010.

The resource usage of transportation combined with industrial output results in the release of 11,700 tons of pollutants into the air each day or about 4.3 million tons per year. Trends over the last decade indicate that pollution levels could double in the next 12 years, with obviously serious pollution consequences for the population. The principal constituents of atmospheric air pollution are ozone, particulate matter, nitrogen oxides, sulfur oxides, and carbon monoxide.

Zero Emission Bus Demonstration Project

In June 1997 a seminar and exposition on clean vehicles was held in Mexico City to review the state of the art of several clean vehicle technologies, including Proton Exchange Membrane (PEM) fuel cells. To showcase this technology, Ballard Power Systems displayed and demonstrated the world's first full-size, zero-emission PEM fuel-cell-powered transit bus. This demonstration project was undertaken by Ballard Power Corporation and Science Applications International, with funding provided by the U.S. Environmental Protection Agency.

The general goal of the project was to raise public awareness of the existence, and advanced stage of development, of this technology that could contribute significantly to reducing pollution from transportation sources. The technical goal of the project was to document and characterize the performance of a transit bus using PEM fuel cells as its power source in the atmospheric environment of Mexico City.

The bus was successfully operated during the conference with considerable interest shown in it. The bus was demonstrated by providing rides to government officials, political leaders, members of the press, members of vehicle programs, and the general public. Data were collected throughout the operation of the bus to evaluate its performance at the elevation of Mexico City, and to determine if there is any effect from the ambient street-level pollution.

Zero-Emission Fuel Cell Technology

The Ballard Fuel Cell Engine that powers the bus uses a fundamentally different method of generating power; however, it retains many of the attributes of a conventional engine. Like traditional internal-combustion engines, the fuel-cell engine combines fuel and air to create power. Compressed hydrogen fuel is stored in an external tank that can be quickly and easily refilled, providing the vehicle with the required range of travel.

A fuel cell converts the chemical energy in the fuel directly into electricity through a low-temperature electrochemical process. This direct conversion has no intermediate thermal or mechanical stages, so the efficiency is high. No combustion is involved, so there is no pollution. The only exhaust from a fuel cell is water vapor. The electricity produced by the fuel-cell engine is supplied to electric motors that power both the vehicle's drive wheels and auxiliary equipment.

Technical Conclusion

Overall, the PEM fuel cell powered the Phase 2 Bus operated in Mexico City as anticipated, given the conditions present at that elevation. The performance of the fuel-cell engine is significantly dependent on its air subsystem to provide oxidant to the fuel cell at the correct pressure and flow rate. Due to the high elevation of Mexico City, there was a reduction in air subsystem efficiency of about 28%. This reduced air flow caused a reduction of engine power output of about 22%. The atmospheric pressure at Mexico City's elevation is approximately 29% less than that at sea level. The contaminants in the Mexico City atmosphere did not have any apparent effect on the bus engine operation over the time frame of this demonstration.

As a general conclusion of the operating experience in Mexico City, there does not appear to be any reason that fuel-cell buses cannot be operated successfully in that environment. The air subsystem is the key to efficient and reliable operation of the fuel-cell engine in any environment, and, if the unusual elevation of the city is taken into account in sizing the compressor, there should not be any particular limitation to bus operation under those conditions.

Tom Gilchrist is with Ballard Power Systems, Inc., Burnaby, B.C.
Ronald J. Spiegel *is the EPA Project Officer (see below).*
The complete report, entitled "Fuel Cell Bus Demonstration in Mexico City," (Order No. PB98-142 037 ; Cost: $23.00, subject to change) will be available only from

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at

Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

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