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Fuel cell mobile lighting: A fuel cell market transformation project

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ARTICLE INFO

Article history:
Accepted 28 May 2014
Available online 9 July 2014

ABSTRACT

We report the results of a project aimed to introduce proton exchange membrane (PEM) hydrogen fuel cell technology into aviation ground support equipment (GSE) and rental construction equipment. The purpose of the project was to design, build, field-test and then commercialize fuel cell equipment that is superior to its diesel counterpart. The commercializing of this hydrogen-based technology will help to start the process of

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http://dx.doi.org/10.1016/j.ijhydene.2014.05.180

Keywords:
Fuel cell
Market transformation
Mobile lighting
Construction equipment
Ground support equipment

displacing diesel fuel use in aviation GSE and in mobile construction equipment. We describe a hydrogen fuel cell mobile lighting tower (H_2LT) that combines hydrogen stored as a high pressure gas, PEM fuel cell technology, and advanced lighting into a single unit with uses in aviation and construction. We assembled a project team of 15 institutional partners combining new technology expertise (hydrogen, fuel cells), equipment mass manufacturing capability (mobile light towers, lighting) and influential end-users to field test the H_2LT in real-world use in diverse environments. Seed funding provided by Boeing enabled additional funding from the U.S. Department of Energy (DOE) and a preponderance of in-kind contributions from the industrial partners. Prototype units were constructed and field tested in the entertainment industry, at the San Francisco International Airport, at the NASA Kennedy Space Center, with the California Department of Transportation (Caltrans), and with the Connecticut Department of Transportation. The goals of these approximately year-long field tests were to assess operation of the H_2LT technology in a wide variety of potentially corrosive environments (cold, wet, hot, humid, salty air) performing a wide variety of tasks, to reduce diesel emissions at these locations, and to help promote hydrogen PEM technology in new influential markets. The H_2LT proved to be exceptionally durable in these diverse environments, demonstrating the compatibility of PEM fuel cells and high-pressure hydrogen storage with the construction equipment application. Results from the field tests are discussed, including system performance (efficiency, duration, durability) and the efficacy of refueling the system by different methods (H_2 stations, mobile refueling). The H_2LT system is compared directly to a comparable diesel-fueled light tower with regard to size, performance and emissions savings. Overall, end users were pleased with the performance of the H_2LT, noting the lack of emissions and exceptionally low noise level. Recommendations for improvement were also collected and will be discussed. Two types of lighting used on the H_2LT (plasma, LED) were characterized by U.C. Davis in collaboration with Caltrans. LED lighting was found to be the most energy efficient and robust lighting technology for the highly mobile H_2LT application. The technical "lessons-learned" are reviewed, along with the plans for commercialization of the H_2LT technology by Multiquip Inc. Finally, the benefits to the industrial participants of the project organization are described.

Introduction

This paper describes a project to bring hydrogen proton exchange membrane (PEM) fuel cell technology to aviation ground support equipment (GSE) and general construction equipment in the form of a hydrogen fuel cell mobile light tower (H_2LT). The project brought together new technology holders, mass manufacturing capability, and end-users to produce a superior zero-emissions commercial product that could be purchased, starting reductions in greenhouse gas (GHG) emissions in the construction equipment and aviation GSE realms.

Hydrogen fuel cell systems have the potential to provide high-efficiency and eventually low-cost power for portable equipment. Keller et al. has reviewed the attributes of hydrogen-based power for zero-emissions transportation technology [1], while also describing the history and worrisome magnitudes of the GHG emission and global climate change problems. PEM fuel cell systems and their use in automotive and portable power technology were recently reviewed by Klebanoff and co-workers [2]. The reader is directed to these references for a full description of hydrogen and PEM fuel cell technology and how hydrogen fuel cells can mitigate global climate change. The use of fuel cell portable construction equipment represents a good early market introduction of fuel cells, thereby supporting fuel cell market growth. The current diesel-based mobile light tower market is approximately 100,000 units in the United States, thus representing a niche market within the construction equipment realm, but a good starting point for introducing fuel cells into construction equipment and aviation GSE.

We begin with a discussion of how the project was initiated by The Boeing Company as well as the formation of the project team consisting of 15 institutional partners spread across industry, state government, and other entities. The elements of the H_2LT system design are described, and the H_2LT is directly compared to a comparable diesel-powered light tower with regard to size, performance and emissions. An account is then given of the field-tests in a number of challenging environments meant to test the physical durability and performance of the system, stimulate hydrogen fueling resources at the test sites, reduce diesel emissions at these locations, and promote fuel cell technology in new impactful markets. Finally, we review the design "lessons-learned" from the field-tests (which will fold into the final commercial design), discuss