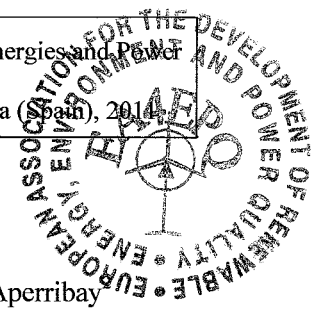


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## PEM Fuel Cells in Applications of Urban Public Transport

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**Abstract.** This paper is focused on the analysis and design of an electric bus, powered by fuel cell and solar modules. The system uses a 400 V DC bus, interconnected by electronic converters with photovoltaic modules, batteries, ultracapacitors, fuel cell, electrolyzer, propulsion engines and conditioning devices.

This arrangement allows the energy exchange between devices in an optimal way, allowing also the recovery of braking energy via the inverter, to charge batteries and ultracapacitors, or to generate hydrogen using the electrolyzer.

### Key words

Clean Urban Transport, Hydrogen, PEMFC, PV, Ultracapacitors.

### 1. Introduction

Nowadays a new concept in urban public transport gets more and more interest in order to satisfy the energy needs of this sector, with high efficiency, reduced harmful emissions and diversification of fuel use. In this context, fuel cell is a very interesting device. It satisfies the above requirements and adds its quiet operation, modular nature and low maintenance. In recent years, various types of fuel cell buses using different propulsion systems and strategies for energy management have been researched and developed [1-2].

Thus, the Clean Urban Transport for Europe (CUTE) pilot project was carried out by DaimlerChrysler and financed by the European Commission. The project's aim was to demonstrate and evaluate the new technology used by Citaro fuel cell buses, including hydrogen fuel infrastructure. In this project, 27 buses in nine cities (Amsterdam, Barcelona, Hamburg, London, Luxembourg, Madrid, Porto, Stockholm and Stuttgart) were evaluated. In each city, 3 buses were operating in a period of twenty four months. The bus that operated in Madrid, became operational in May 2003. Other buses started its operation in autumn 2003 or early 2004. Cities had different hydrogen supply infrastructures and the buses operated under different conditions, such as: flat or hilly cities, scheduled and unscheduled bus lines, cold and wet or hot and dry climates.

From the analysis of the CUTE project results, it is noteworthy that efficiency, reliability and durability of fuel cells have surprised the institutions that covered the project. Therefore, they decided to extend the experience with the project HyFLEET: CUTE. The project brought together 31 participants, including Iceland, Australia and China [3].

In this paper, aspects related to the design of a fuel cell based bus are presented, covering characteristics of the different components and design criteria.

### 2. Clean fuels and propulsion systems for transport

Since years ago, the EU has been trying to promote the use of biofuels as substitutes for diesel or petrol for transport. As a result, the Directive 2003/30/EC [4] was developed in 2003, to promote the use of biofuels. This Directive requires all EU members to ensure that before December 31<sup>st</sup>, 2010, at least 5.75% of transport fuels will be biofuels. There are several reasons for promoting the use of biofuels, which include:

- 1) Reduce the energy dependence of the European Union countries.
- 2) Stabilize prices of fossil fuels.
- 3) Reduce emissions of greenhouse gases.
- 4) Promote demand for agricultural products.

Among the different existing fuel options, the parameter used to compare alternative fuels to gasoline and diesel, is the price per unit of energy, in terms of LHV.

Currently, due to the state of technology development and costs associated with production, the consumption of biofuels is not yet cost-effective [5]. On the other hand, it should be noted that in some European countries, which have a strong primary sector, a high percentage of raw materials used to produce biofuels is imported. This fact calls into question the aim of the European Directive mentioned above, to reduce dependence on foreign energy. So, hydrogen can be an alternative to gasoline, diesel and biofuels for the automotive sector. Depending