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New Materials for Non-Pollutant High Technology Buses

Paulo Emílio V. de Miranda[1,2], Edvaldo da Silva Carreira[2]

[1]Editor-in-Chief
Matéria Journal
E-mail: pmiranda@labh2.coppe.ufrj.br
[2]The Hydrogen Laboratory, Coppe-Federal University of Rio de Janeiro, Horácio Macedo Ave., 2030, I-146, 21941-914 Rio de Janeiro, RJ, Brazil

An evaluation of the sequence utilized by our society to select fuels that have been used for energy production [1] shows a continuous and progressive path from carbon-richer fuels, such as wood and coal, to others that are richer in hydrogen, such as oil and natural gas. This shows a clear tendency of fuel decarbonization to eventually reach an era of hydrogen predominance as the main source of energy. However, nowadays we are still strongly based on fossil fuels and on the inefficient internal combustion machines. One of the noticeable consequences of this option is the environmental pollution, affecting deleteriously the planet and the living beings. Among the known types of pollution, much attention is given to those that are responsible for the green-house effect contributing to the increase on the earth temperature and on the oceans' level. However, it has been recently announced [2] that particulate materials emitted by the transport media, may be very much malefic to the humankind.

The scenery above mentioned claims for engineering solutions and for adequate materials aiming the decrease of the environmental impact experimented by the urban metropolitan regions through their transportation sector. The noise above the acceptable limits for human comfort, the characteristic energetic inefficiency of the thermal machines and the unspeakable pollution that harms the planet and its inhabitants do not fit any more in the simplified speech considering the "smaller" selling cost of the present vehicles compared to more modern technology. In the huge urban centers where busses are intensively used, such as Rio de Janeiro, Bogotá, Mexico City, New Delhi or Beijing, the situation is still more calamitous because of the utilization of diesel, a great urban polluter. The option for vehicles with electrical power train is not new, considering the successful experiences accomplished in the beginning of the twentieth century and rapidly surpassed by the opportunity to use oil byproducts, but it is innovative when a hydrogen fueled fuel cell is gathered to it as an embarked electrical energy generator.

Considering the great modern urban centers, it is not worth to encourage the use of personal vehicles, the automobiles that fill the streets up in such a way that its utilization today gives the mere illusion of power on personal mobility. It is convenient, then, to make the option for high quality mass transportation, which is achieved with the use of hydrogen fuel cell hybrid-electric bus. There are multiple advantages because the vehicle is very silent, as it is typical for electric power train vehicles, it does not pollute the environment, its waste is no more than water vapor, it is very energy efficient, breaking the links with the wasteful thermal machines, and, last but not least, it utilizes hydrogen as a fuel and air oxygen to produce electricity. Hydrogen, the safe use of which has been well established by engineering, is an inexhaustible fuel that may be produced from several different raw materials, including water and biomasses. This gives hydrogen the characteristics of being renewable and of possessing availability that is independent of geographic localization, contrarily to which is true for the fossil fuels.

Several experiences were made throughout the world developing and prototyping hydrogen buses. The major program in this area was implemented between 2001 and 2006, utilizing 27 buses in nine different European cities, testing the vehicles with public and all the refueling, operation and maintenance system. It was denominated CUTE – Clean Urban Transport for Europe[3]. Although fundamental for learning about the use of the new technology, CUTE has used buses that were totally energized by hydrogen fed fuel cells, with performance of 25 kg of hydrogen spent per 100 km. However, the new European program, called CHIC – Clean Hydrogen in European Cities[4], began in 2010 aiming to be kept active until 2016 in 5 European cities. It utilizes an embarked electric energy system that allowed reducing the fuel cells power and represented a considerable performance improvement to reach about 12 kg of hydrogen spent per 100 km. Other projects have been demonstrated in Canada, in South Korea, in Japan and in China and operation performances of about 10 kg of hydrogen spent per 100 km have been reported [5].

In Brazil, the Federal University of Rio de Janeiro has developed new technology for hydrogen buses, introducing the important characteristic of the energy hybridism. In such case the vehicle is plug-in type, recharging its electric energy storing system before leaving the garage, utilizes low-power fuel cells and makes very effective use of the regeneration of kinetic energy into electric energy in deceleration and breaking processes. The project has given emphasis to the embarked energy hybridization engineering and has made proprietary developments of the equipment used in the power train and auxiliary systems, all of them functioning with the use of electric energy. A drastic reduction in the fuel cell power and functioning mode because of the hybrid configuration used, the emphasis given on the kinetic to electric energy regeneration and the advances made in the energy hybridization engineering onboard resulted in overwhelming performance benefits to reach about 5 kg of hydrogen spent per 100 km and energy efficiency of 48.2% as demonstrated in the Sankey graph of Figure 1.

The development of high-technology modern buses represents a great challenge to the area of materials. The reason for that is because; in spite of the recent and innovative devices which require new engineering configurations and new materials, the conventional vehicle parts must be looked over with the objective of decreasing dead weight to contribute to the energetic efficiency. That is why components that are nowadays fabricated with steel should be substituted by aluminum alloys and high-strength composite and polymeric materials. In addition to that, electric powered vehicles call for the use of electric energy storing systems that make use of rare-earth metals, for which recycling methods have yet to be better established. The low-temperature fuel cells, usually employed in such application, need to use noble metals, ionic conducting sulfonic polymeric membranes and carbonaceous materials that involve highly specialized fabrication procedures yet dependent on new procedures with alternative compositions to allow the desired improvement in performance and cost decrease. Articles about these themes are very much welcomed for publication in the Materia Journal.

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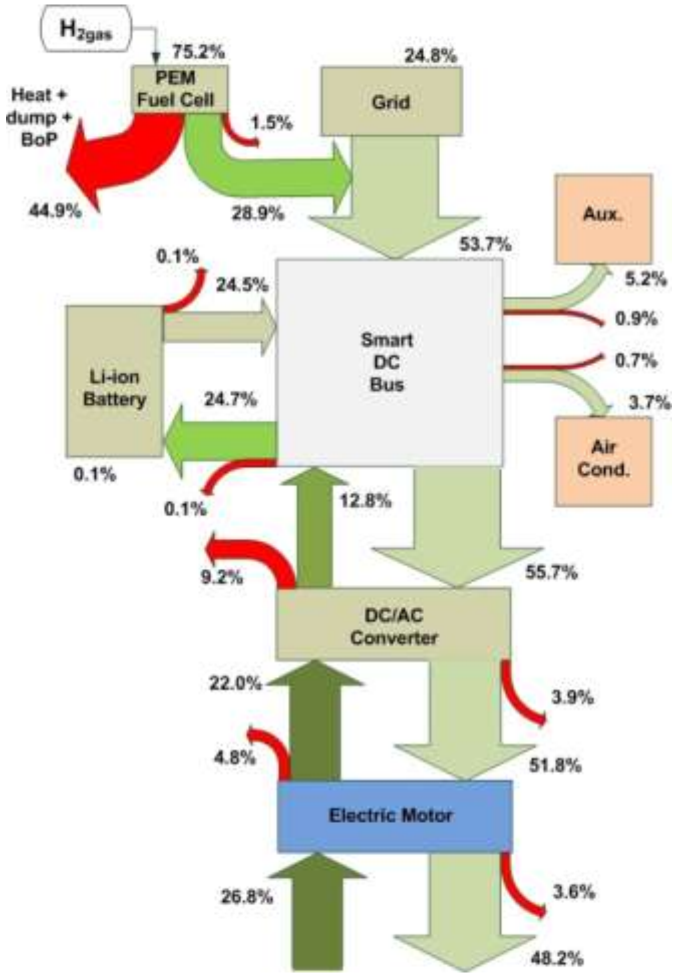

Figure 1: Sankey graph showing the energy expenditures in the bus power train and auxiliary system. It demonstrates that 48.2% of the total initial energy stored onboard is effectively used to power the vehicle traction motor.