Design and Implementation of Renewable Hydrogen Fuel Cell Vehicles

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Abstract. In this paper, a systematic approach for investigating a hydrogen fuel cell hybrid vehicle system is considered. This approach involves developing a mathematical model incorporating renewable hydrogen production, storage and refuelling of the fuel cell vehicle system. The University of Glamorgan's (UOG) Sustainable Environment Research Centre (SERC) have developed the UK's first alternative energy refuelling facility at the University's Hydrogen Centre in Baglan. Hydrogen produced from renewable energy on-site will be use to refuel the UOG, Faculty of Advanced Technology, Hydrogen Bus (UOGHB). The simulation model is used to analyse the effect of operating conditions and energy demand of the UOGHB. Comparisons are made between the simulation results from the mathematical model and UOGHB experimental data. A general agreement exists but where disagreements and anomalies occur, reasoned arguments are presented in explanation. The model represents a reasonable overall representation of the UOGHB. This model can be used for controller development, to improve operational quality and performances.

Key words
Hydrogen Fuel cell Vehicles, Hybrid system, Modelling, Model validation, Power system

1. Introduction

The global aspiration to increased affluence, welfare and consumerism, while accommodating increased populations, will almost certainly result in increased global energy demand. Unless this demand can be met, the number of people who will be affected by energy shortage is likely to increase several folds. Energy shortages would be further exacerbated by fiscal and economic measures which may be required to mitigate green house gas (GHG) effects caused by burning fossil fuels. Hydrogen as an energy carrier is of considerable relevance in such circumstances, primarily because it may be produced from several renewable resources, through a number of technological routes [1]. Many of the renewable routes to hydrogen are still at the research and development stage, e.g. bio-hydrogen production from various biomass feeds, including food, co-products, energy crops and sewage sludge. However, it is important to realise that hydrogen energy is still relatively expensive to produce, install, operate and maintain. However, the gap is narrowing, particularly if externalities such as GHG are costed for all, including fossil fuels. Hydrogen as a fuel still has significant progress to make before realizing an economically feasible and safe vehicle [2]. The objective of this work is to investigate energy efficient hydrogen fuel cell hybrid vehicle systems which are less expensive to operate, and can be used as an alternative to fossil fuel vehicles.

Fuel cell (FC) based vehicles are increasingly being researched to satisfy the market need for a low emission means of transportation. Besides being a green mode of transportation, fuel cell based vehicles also promise efficient and quiet operation, which makes them an attractive proposition [3], [4]. However, in order to have an efficient economic fuel cell hybrid vehicle, it is important that the fuel consumption rate be kept low and that the energy loss be minimized. Furthermore, energy requirements for the vehicle need to be minimized [5].

This work address the issues relating to the development of new low emissions tribrid vehicles through the use of new technologies and materials along with the use of renewable energy. In particular, the paper will focus on the development and simulated implementation of renewable hydrogen fuel cell tribrid vehicles. The main purpose of the paper is to employ a simulation model for a generic hydrogen fuel cell tribrid vehicle with reference to the UOGHB. The model is then used to analyse and improve the performance of the vehicle. A description of the powertrain topologies and experimental setup are described in Section 2 and followed by the simulation model of a hydrogen fuel cell vehicle in Section 3. Finally, validation of the hydrogen fuel cell vehicle (HFCV) is presented through the simulation results and brief analyses of these results are described in Section 4.