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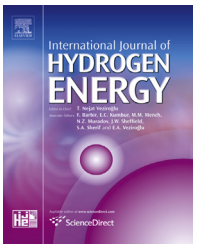

Consumer attitudes to fuel cell vehicles post trial in the United Kingdom

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ABSTRACT

Fuel cell cehicles (FCVs) have clear societal and environmental benefits and can help mitigate the issues of climate change, urban air pollution and oil dependence. In order for FCVs to have the biggest impact on these issues they need to be employed in large numbers. First, though, they need to be adopted by consumers. Their acceptance depends on positive consumer attitudes towards the vehicles. Currently there is a limited understanding within the literature on how consumers perceive FCVs and what the likelihood of adoption by consumers would be, despite significant governmental and organisational investments into the technology. Therefore this study assesses consumer attitudes towards FCVs in the United Kingdom. 81 persons drove a Hyundai FCV at the Low Carbon Vehicle Event in September 2015 of which 30 took part in this study. The results show that at present FCVs are perceived mostly as being similar to incumbent internal combustion engine vehicles. This is an admirable technical achievement, however in order for consumers to adopt FCVs they will need to be perceived as having distinctive benefits. Two significant barriers to the adoption of FCVs are observed in this sample: high costs and lack of refuelling infrastructure. This paper goes on to make suggestions on how and which beneficial attributes of the vehicles can be promoted to consumers and also makes suggestions on how the barriers can be overcame so that FCVs will be adopted by consumers.

Introduction

The widespread deployment of fuel cell vehicles (FCVs) is important because of the societal and environmental benefits that they possess [1–5]. Policy makers are keen to see FCVs taken up by commercial organisations and by consumers as they can help solve the long-standing issues of global climate change, urban air pollution and energy security [6–8]. Furthermore they have the potential to contribute toward grid power balancing, as any oversupply of power can be stored as hydrogen gas to be later used in a FCV [9]. This is likely to become a problem due to growing market shares of intermittent renewables, predominantly wind and solar in electricity grids. However, in order for FCVs to contribute to solving these issues, they will need to be adopted by consumers.

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FCVs are approaching market entry, with recent developments by some of the worlds largest automotive companies meaning there are now commercial offerings. These vehicles are an innovation, an innovation is any new technology, product or idea that is perceived as different from the current technology used by consumers [10]. FCVs contain many new technologies, including the fuel cell (FC) its balance of plant and the electric motors. The way in which the vehicles are refuelled is also different to that of an ICEV, requiring hydrogen fuel. These differences mean the people who will adopt them perceive the vehicles as being an innovation. Thanks to Rogers' Theory [10] it has long been understood that in order for consumers to adopt an innovation, it needs to have 'relative advantage'. This means that an innovation needs to be perceived as better than the technology that it supersedes. If a technology is merely perceived as similar to the incumbent, consumers will not be motivated to adopt it. This is especially true when an innovation is more expensive than the preceding technology [10–13]. FCVs are more expensive than Internal Combustion Engine Vehicles (ICEVs) and Battery Electric Vehicles (BEVs), with the expectation of Tesla BEVs, which cost US$70,000–105,000 [14]. This situation could change in the future with higher volume productions of FCVs, but the same can be said for BEVs. Nevertheless in the early market FCVs will exceed the price of an average ICEV and most BEVs. Therefore they must have relative advantage. This must be a clearly perceived from the point of view of the consumer, not societal and environmental benefits which are the concern of policy makers. Innovations that lack relative advantage suffer from slow rates of adoption, and when adoption does occur discontinuance is high [10].

This paper presents data from 30 participants in a FCV trial in the United Kingdom (UK). The aim of the study was to assess consumer attitudes toward FCVs with the objective of understanding what their perception of the relative advantage of the vehicles is. In doing so, a greater understanding of the likelihood of successful FCV market entry can be gained. This sample is unique as it is the first in the UK and Europe to assess the attitudes toward FCVs in this region. It is only the second study globally to do this, with the first being in the USA in 2009 [3]. It is the first study to assess attitudes of consumers who have driven both a FCV and a BEV. This is important because consumers are likely to have the choice between a BEV and FCV with future vehicle purchases. Previous studies have only considered FCVs in comparison with ICEVs, and do not pay attention to the implications a further choice between FCV and BEV can bring to consumers. This limitation was mentioned by Ref. [15] who called for FCV research to be conducted in the context of both ICEVs and BEVs. The FCV in this study is the Hyundai IX35 FCV, which was the first commercially available FCV on the market [16]. The characteristics of this vehicle can be seen in Table 1, in comparison to a Hyundai IX35 ICEV.

Table 1 – Features of the Hyundai IX35 FCV compared to its ICEV counterpart [17,18]. Note that in some markets the Hyundai IX35 is marketed as the Hyundai Tucson.

	Hyundai IX35 FCV	Hyundai IX35 ICEV
Price	£53,000	£18,695
Range	369 miles	611 miles
Refuel time	10 minutes	3–5 minutes
Acceleration (0–60mph)	12.5 seconds	11.5 seconds
Top speed	99 mph	113 mph
Efficiency (mpge)	51 (US EPA)	44.8 (NEDC)
Fuel running cost (estimate)	15p/mile	11p/mile

Existing fuel cell vehicle literature

Previous research into FCVs has suggested that barriers to adoption of the vehicles include high costs, lack of infrastructure, and perceived safety issues [15,19–23]. All of these suggestions are made without empirical evidence from people who have experience with a FCV. They either use case study data, or gather evidence from members of the general public and ask them questions about their opinions of FCVs. None of the consumers in these studies have ever driven a FCV. Therefore the data is only based on consumers' estimations of what the vehicles might be like. This data may not yield meaningful results as only 8% of the general public have been found to have good knowledge of FCVs [24]. Within the literature there is one exception: the study undertaken in California in 2009 by Martin et al. [3] allowed people to drive in a FCV before giving their opinion. This study found that consumers did not have safety concerns and the ride and drives were found to improve consumer perceptions of FCVs. The study is now 6 years old, therefore may be out of date due to technological advancements in FCVs and also due to changes in the nature of the automotive market which now contains close to three quarters of a million BEVs [25]. A further potential limitation of that study is that the results could potentially be biased due to participants not being random. Respondents were from agencies such as California Air Resources Board, California Fuel Cell Partnership and from universities. This sample may have more positive opinions of FCVs than the general population due to the background of participants.

Methodology

Respondents were recruited for this study at the Low Carbon Vehicles 2015 event in Millbrook, UK. The event is an annual showcase of low emission vehicles, including advanced ICEVs, HEVs, PHEV, BEVs and FCVs. In 2015 there were 2852 visitors to the event and 103 low carbon vehicles were on display. Visitors to the event have the opportunity to take the majority of the vehicles on display out on test drives. The test drive route is at the Millbrook Proving Ground in Bedfordshire, UK. The route involves a drive around the 5 km Alpine Handling Circuit and the 3.2 km High Speed Bowl. This allows drivers to experience braking, acceleration, road handling, and the top speed of vehicles. This event was selected as it would attract persons who have interest in BEVs and FCVs therefore may be potential early adopters. This means that the data will not be representative of the general population's opinions of FCVs; but it is still valid, though, as data that will be indicative of the opinions that early adopters have of FCVs. This is important

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