



*Public perceptions of hydrogen fuel cell  
vehicles on the Island of Tenerife*



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# Report: Public perceptions of hydrogen fuel cell vehicles on the Island of Tenerife – Results from focus groups

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## Executive Summary

**Aim:** The overall aim was to identify and invite relevant stakeholders, including local communities and SMEs to a series of meetings to gather information on the potential benefits of implementing the hydrogen fuel cell technology on the Island of Tenerife. This was facilitated via four separate focus groups which were conducted with tourists and local car hire company managers. The findings of which will be used to inform the design of a survey for tourists' assessing their knowledge and preferences for hydrogen fuel cell cars. This document reports on the results of the focus groups and deriving the attributes for the choice experiment.

**Methods:** First, an extensive literature review was undertaken which examined EU policies in relation to hydrogen and transport and the factors affecting the demand for alternative fuel vehicles in different countries. The findings were used to inform the interview schedule used for four focus groups conducted on the Island of Tenerife; three focus groups with tourists currently staying on the Island and one focus group with car hire company managers working in the community. The focus groups were lead using a structured interview schedule involving open-



ended questions to determine perceptions, opinions, beliefs and attitudes towards hiring hydrogen vehicles. The focus groups were transcribed and thematically analysed to classify the concepts raised into themes and sub-themes. Finally attributes and levels were identified that took into account both the findings of the focus groups and the purpose of the main choice questionnaire methodology.

**Results:** Six attributes were derived and proposed to be included in the next stage of a face to face discrete choice experiment with tourists visiting the island of Tenerife.

**Discussion:** Input has been sought from tourists and local car hire managers on the island of Tenerife to try to ensure that the attributes and levels were appropriate, measurable and relevant. The discrete choice experiment will be used to elicit consumers preferences and demand for hiring hydrogen vehicles on the Island of Tenerife.

## 1.0 Introduction

The adoption of technologies that underpin sustainable transport is crucial for climate change and the energy transition (Iribarren et al., 2016) and in particular to enable member states to meet targets set by the European Commission, such as a reduction of 60% of transport related CO<sub>2</sub> emissions by 2050 (Hoen and Koetse, 2014). Additional goals include replacing 10% of conventional fuels with biofuels, hydrogen and ecologically sourced electricity by 2020 (Fúnez Guerra et al., 2016). Hydrogen fuel cells for transportation offer an important means by which to diversify automotive fuel sources and supply (Ball and Wietschel, 2009; Southall and Khare, 2016; Ambrose et al., 2017). A number of important advantages particularly for island economies dependent on tourism but with abundant renewables, energy security concerns and rising transport costs along with limited opportunities for interregional electricity transmission pose great challenges (Alves et al., 2000; Krajačić et al., 2008; Matera et al., 2009; Eleanor Denny, 2012; Gils and Simon, 2017).



However, a successful transition to a low carbon transport system on Islands is contingent upon the widespread adoption of alternative fuel vehicles (Al-Amin et al., 2016) amongst a wide variety of stakeholders groups including the general public and the commercial sector (Mourato et al., 2004). This report is mainly concerned with the former and focusses on understanding the factors that influence demand and consumer preferences (including intended behaviour and attitudes) for the rental of AFCV by visiting tourists on an island setting using Tenerife, Spain (Askjellerud 2003) as a case study site for the SEAFUEL project. The work will also contribute more broadly to an understanding of preferences of consumers towards hydrogen end-use technologies in the transport sector.

Although technology is widely believed to be a solution to climate change, the social adoption and diffusion of such technologies is not without its difficulties (Rogers, 1995; Edelenbosch 2018). Numerous factors are thought to influence HFCV by the general public including lack of hydrogen infrastructure (Kim et al., 2008), safety concerns (Mourato et al. 2004), prior experience (Schulte 2004), information, fuel source, and vehicle running costs (Southall and Khare 2016) to name but a few.

We are not aware of any other studies that evaluate consumer preferences, or define the factors that influence early adoption of AFC rental vehicles powered from a renewable source in an island setting using choice experiments. Choice experiment studies typically involve a review of the literature (action 1 WP 7), a series of focus groups (action 2) used to inform the development of the survey and define the attributes used in the choice experiment and a public survey (action 3). This report outlines the process used to conduct the focus group research. We begin by defining the project aims and objectives.

## **1.1 Project aims and objectives**

**The project objectives are:**

- 1) To determine public preferences towards hydrogen end-use technologies in the transport sector on the Island of Tenerife.



- 2) To identify the attributes and levels of importance to be used in a discrete choice experiment.
- 3) To elicit preferences and assess intended behaviour and attitudes towards hiring hydrogen cars on the Island of Tenerife by administering a survey using a discrete choice experiment.

*This report briefly outlines the Phase 1 focus groups and details Phase 2 deriving the attributes for use in an online discrete choice experiment. Phase 3 is planned to take place in January 2020.*

## **2.0 Methods**

### **2.1 Phase 1: Determining stakeholders views on hydrogen**

#### **2.1.1 Focus groups**

Focus groups provide insights into the sources of complex behaviour and motivations because they allow for interaction. Focus groups are also thought to provide a more complete picture of the research topic, allow scope for consensus or compromise reaching, for clear identification of points of disagreement whereby participants query each other and explain why their views might differ. Spiess et al. (2015) reports that compared to survey methods, focus groups enabled data representing the views of a broad variety of stakeholders to be collected very efficiently. This is not possible using individual surveys which tend to be better at getting yes or no answers, determining the prevalence of attitudes and experiences and at gathering information on sensitive topics.

Typically most studies consist of 4 to 6 focus groups particularly where group segmentation or replication is involved (Morgan, 1996). However, group segmentation by gender, socioeconomic status or geographical location was not central to our research. The small sample size per focus group is not deemed to be an issue as successful studies have been conducted with as few as 3 participants, and there are diminishing returns to new information provision as group sizes increase (Fern et al., 1982).



The focus groups were organised by a Tenerife based survey company and took place at one of the largest five star hotels on the Island of Tenerife in June 2019. Tourists staying at hotel were approached and recruited on site by the survey company. Interested participants were invited to attend a focus group on site with 24 hours notice. As an incentive to participate, participants were given tickets to local tourist attractions. Local car hire companies were contacted and managers were asked to attend the focus groups. Including car hire managers in the focus groups helped to inform the consumer survey (action 3). Two researchers ran the focus groups, one moderated the groups and the second tape recorded and transcribed the sessions and built rapport and recorded the group dynamic. The general format of both sets of focus groups was as follows: The presenter provided some background on the study and indicated that the aim of the focus groups was to explore their opinions and views regarding the topic. To gauge baseline knowledge participants were then asked why they had attended the focus groups to gain insight into their understanding of 'hydrogen'. Participants were then asked for their consent, assured of the confidentiality of their responses and then introduced to one another. The focus groups were held in a local hotel in Tenerife and refreshments were offered to participants.

The moderator introduced a number of open topics/questions to allow for a range of insights into the issue and these were considered by all four focus groups. An indicative interview schedule was generated using a review of the literature and keeping in mind the overall aim of the study. These broad topics are listed below:

- Alternative fuel cell technology - benefits and challenges
- Using a hydrogen vehicle - fuelling up, expectations on driving range
- Information - what would be useful to them
- Incentives to encourage uptake

Crucially, this approach enabled the data from the public focus groups and the car hire focus groups to be compared. The discussion was kept open and the moderator would intervene only if the debate deviated significantly off topic. No strict time limit was imposed by topic and the moderator ensured as far as



possible that everyone participated in the discussion. Each focus group was approximately 60 minutes in duration.

The early part of the public focus groups were kept broad and began by obtaining information on their knowledge and experience of hydrogen, positive and negative impacts, experience of and attitudes toward hydrogen, information provision, who should be involved in the deployment of hydrogen for mobility.

### 2.1.2 Analysis

The analysis was undertaken using a qualitative thematic analysis that is used for focus group data (Kruger, 2014). The data was recorded and transcribed by the researchers who conducted the focus groups. Two members of the research team (TVR, AH) independently read and re-read one of the tourists transcripts and another read one of the car hire manager transcripts, while listening to the audio-recordings, to become familiar with and get a feel for the content of the data. One member of the research team independently coded the focus group transcripts in hard copy. Segments of text deemed important or interesting were underlined and a label (theme) was written in the left-hand margin. These themes were informed both by a priori themes included in the focus group interview schedule and new codes emerging from the data. The two researchers (TVR, AH) met in order to discuss the interpretation of the data, and its general findings and use in informing the DCE. Further discussion with the wider research team was then undertaken through conference calls, workshops, and presentations.

## 3.0 Results

In total twenty two participants took part in the focus groups, sixteen tourists and six car hire managers participated. The results of the thematic analysis were separated into four main themes and subthemes for both groups and are presented in Table 1 and 2 below: The four themes identified include: *benefits of hydrogen technology*, *challenges with hydrogen technology*, *information and experience and incentives*. Each theme was raised as being important by both tourists and the car hire company managers. A final list of attributes and levels





were drawn from the findings to be used for the choice experiment and is presented in section 4 below.

### **3.1 Table 1 Key findings from tourists:**

<b>Benefits of hydrogen technology</b>	Hydrogen is perceived as good for environment, less CO <sub>2</sub> emissions, less time to refuel, good driving range. Consistent message that hydrogen is good for the environment but there was a lack of knowledge of how hydrogen is produced. Distinctions between GHG emissions and air quality and human toxicity not clear. Hydrogen perceived as primary power or at least a power source not a carrier by many respondents.
<b>Challenges with hydrogen technology</b>	<p>The participants raised the issue of range anxiety i.e., the distance the car must travel before having to refuel. Access to refuelling stations was a concern. A general consensus was that 50% of existing stations on the island should have a hydrogen-refuelling unit installed to cover the demand for fuel and ensure sufficient access. Furthermore, technical support would be required with this new technology and would need to be available especially for breakdowns. Participants further stated that there would need to be a good range of models available for tourists to hire but that initially it would be accepted by consumers that this would not be possible. Participants raised the fact that there was a perception about hydrogen and lack of safety and that this was more likely due to the fact that there is a lack of awareness and understanding about this technology.</p> <p>Participants prefer to hire a hydrogen fuel cell car that would be similar to a conventional car - quality &amp; comfort, air conditioning, medium sized car with power and to be able to drive a distance of 500k preferably. Participants were willing to travel to refuel but 15-30 minutes maximum to refuel their car is all they would accept. 90% of the participants said they would not hire if hydrogen source was not green.</p>



<b>Information and experience</b>	Confusion over hydrogen source - perceived as primary power source not carrier by respondents. Information and experience needs require a response by relevant authorities. There is a need for the opportunity to test-drive the vehicle. They said a test drive is essential for acceptance of a new technology and this allows the person to get familiar with the car and build trust in its technology. Participants suggested increasing awareness through local advertising on the radio and television. They also said that school children would benefit from some education on these technologies to help increase understanding and acceptance of the technology.
<b>Incentives</b>	Offer a cheaper price per day for hiring the car, designated free parking, park & ride, car-pooling, convenient refuelling, free public transport, discounts on tourist attractions, subsidy for car hire companies, lower fuel price.

### 3.2 Table 2 Key findings from car hire managers:

<b>Benefits of hydrogen technology</b>	Less contamination for the environment, customers more frequently asking about environmentally friendly cars. Refuelling easier than electric, cheaper than traditional car to refuel.
<b>Challenges with hydrogen technology</b>	Sufficient hydrogen stations needed, they also suggested that they would ideally like 50% of regular gas stations to have hydrogen refuelling available. There is a need for trained refuelling attendants and backup support needed if breakdowns happen.  No real consciousness about hydrogen cars, people are unaware of the technology and its source. High costs of maintenance of hydrogen cars was a key issue for car hire managers and they wanted to know if they technology could be re-sold. They talked about the difficulty of changing people's behaviour. They accept less



	choice of cars but groupings should be available. Participants in this group also highlighted safety as a challenge and that there must be a focus on building trust with the technology.
<b>Information and experience</b>	Participants suggested educating people on where power source comes from, on safety, highlight advantages to environment, highlight why people should change from conventional cars to hydrogen fuel cell cars and provide information in school from an early age, documentaries and advertisements in media would be very powerful. Opportunity to test drive the vehicles is needed and Information on how to use the car and how to refuel was seen as important.
<b>Incentives</b>	<p>Transparency on how hydrogen is used, one day free of cost, free backup support service, free parking space, apps / maps showing location of hydrogen stations, information on environmental impact. Use hydrogen in local transport i.e., buses to build confidence.</p> <p>Clear link needed between green hydrogen produced from renewables used for car rental if green attributes is seen as a selling point for the tourism industry. Policy makers need to reflect carefully on enabling regulation and policies on how best to produce green hydrogen, how best to provide it to (early adopter) tourists and how best to persuade early providers (rental companies) to enhance the tourist Island holiday experience over the longer term.</p> <p>Public and car rental company respondents have a preference for green hydrogen but (for public) trade-offs between vehicle attributes, costs and car hire company services reflecting “my Island holiday experience” and environment, costs and hydrogen infrastructure are clearly evident. Signals as to where I will compromise and where I will not are evident.</p>



## 4.0 Discussion of the main findings:

**4.1 Information and experience:** All participants wanted an opportunity to test-drive a hydrogen fuel cell car as was found in Lines et al 2008. Increasing information about hydrogen technology and providing the opportunity to experience the vehicle was seen as very important to all participants. Some suggested using hydrogen in local transport i.e., buses to build confidence and awareness of new technologies in local communities. Achieving social acceptance is key according to Kim et al., 2008 and acceptance depends on positive consumer attitudes towards vehicles, consumer's attitudes post-trial in U.K. see alternative fuel vehicles mostly similar to incumbent internal combustion engine vehicles. California drive clinics show that short-term exposure can improve consumer perceptions of hydrogen performance and safety (Elliot et al 2009).

**4.2 Challenges:** The main barriers to the adoption of new technology on the Island of Tenerife was the perceived lack of infrastructure and high costs associated with it, which has also been highlighted by Hardman 2016 and Lord 2014. In addition to this the high production costs, storage problems, transport and supply problems and high operational costs were key challenges highlighted by Morris and Radu, 2010. More specifically respondents highlighted the need for on call repair, fuel attendant service to be provided, map of refuelling stations, and the ability to exchange for gasoline car at no extra cost and for a full service which is similar to the work done by Lines et al 2008. Safety was raised in both groups, however comparative safety studies of fuel leaks from petrol and hydrogen fuel cell cars performed in Miami, clearly demonstrate that hydrogen-fuelled cars pose less of a fire risk than petrol-fuelled cars (Schlapbach 2009).

**4.3 Incentives:** Participants had many suggestions for incentives to improve the uptake of this new technology, some of which include; one day free of cost, free backup support service, free parking space, apps / maps showing location of



hydrogen stations, information on environmental impact. Priority parking at tourist locations was suggested in Lines et al 2008.

## **5.0 Phase 2: Discrete choice experiments**

Discrete choice experiments have the ability to predict behaviour changes and trade-offs over a much wider range of attribute levels than other simple survey techniques (Johnson, 2013). An added strength of DCE's, is that they extract numerous responses per participant and essentially force participants to make trade-offs between the various scenarios under consideration. The results will provide useful information on participants' relative preferences for various characteristics of hydrogen fuel cell cars, and on their willingness to trade between those characteristics. The results of the DCE surveys will reveal how marginal changes to the delivery of services will influence the demand for hydrogen fuel cell cars. The estimates from the DCE can also be used to estimate preferences in the context of cost benefit analysis and, subsequently, policy analysis.

### **5.1. Deriving the attributes for the choice experiment.**

There are many stages in the development and design of DCE's, typically attributes and levels are derived from a qualitative exercise, focus groups were the chosen method in this study. Attributes were selected and worded using the findings from the initial literature review, the focus group findings and a final ranking exercise conducted with participants. At the end of each focus group, a list of eight attributes with three levels were derived and presented to the participants. All participants gathered around a table to discuss the attributes and their respective levels. Participants were asked to rank the attributes in order of importance. The opportunity to discuss the various attributes and levels and discussions around what participants were willing to compromise / trade off on provided thorough data for the researchers to use as suggested by Coast et al (2012). The feedback allowed the researchers to refine their list and agree on six attributes i.e., four attributes with two levels and two attributes with two levels) to be used for the final discrete choice experiment design. Table 3: Presents the



attributes and levels derived from the focus groups: Six attributes, four with three levels and two with two levels.

**Table 3: Attributes and levels identified**

Attributes	Level 1	Level 2	Level 3
Hire cost	€25	€50	€75
Fuel cost	€5	€10	€15
Driving range	200k	400k	600k
Additional detour time	10 minutes	20 minutes	30 minutes
Fuel source	Green Hydrogen	Not Green	
Car size	Medium	Family SUV	

## 5.2. Description of each of the attributes:

**Hire cost:** The cost of hiring a hydrogen fuel cell vehicle, which ranges from €25, €50 and €75. This cost includes the full comprehensive Insurance.

**Fuel cost:** The fuel cost for the hydrogen fuel cell vehicle per 100km (60 miles). This ranges from €5, €10 and €15 euro per 100k.

**Driving range:** An estimated distance that the car will travel, which ranges from 200k, 400k and 600k.

**Fuel source:** This refers to the source of energy used to make the hydrogen fuel to power the car. Hydrogen can be made from a locally available renewable energy source such as solar or wind power which has zero carbon dioxide emissions and zero sulphur dioxide and nitrous oxide emissions. Alternatively, hydrogen can be produced from imported fossil fuel sources such as gas, oil and coal which does produce carbon dioxide emissions and sulphur dioxide and nitrous oxide emissions. “GREEN” means the hydrogen used to power the car comes from a renewable energy source. “NOT GREEN” means the hydrogen used to power the car comes from a fossil fuel source.



**Car size:** The size of car available for hire is either a medium sized car, which can accommodate up to five people or a large family size vehicle like an SUV, which can accommodate up to eight people.

**Additional detour time:** Not every fuel station offers hydrogen fuel so it may be that you have to drive further to be able to refuel. As the number of hydrogen stations gets lower the additional detour time increases. We want you to consider how far **out of your way** you would be willing to drive to a hydrogen fuel station. The additional detour time could be 10 minutes, 20 minutes or 30 minutes.

## **6. Conclusion:**

Our findings from the focus groups were vital in informing the next phase of the work (action 3) in at least four ways. First, they clearly reveal an interest among the tourist public to consider hiring HFCV while on holiday. They also show an interest among rental car hire companies to supply the market. Second, they confirmed that choice experiments are a highly appropriate method to use to meet the study objectives. Cultural and linguistic differences can sometimes preclude the use of choice experiments as a valuation tool. However, in this instance the focus groups clearly confirmed that the use of a choice experiment is appropriate and that the hypothetical good can be readily characterized into attributes easily understood in a survey of respondents on the Island of Tenerife. Third they were crucial in specifying the attributes and levels to be used in the choice experiment. The attributes and levels were successfully identified and carefully screened and evaluated for use in the choice experiment. These include; hire cost, fuel cost, driving range, additional detour time, fuel source and car size as outlined in detail above.

The fuel source attribute generated discussion among respondents because it was not always clear to all subjects that hydrogen is produced from non-renewable sources. The attributes have now been used in the experimental design for the survey which is currently being pilot tested in Tenerife. Fourth, they were crucial in terms of clarifying a number of factors that may influence early adoption. These include information, experience, socio-demographics, driver



experience and preferences, social norms and social influence and details on the subjects holiday experience. These topics have been built into the survey. For example respondents exhibited a strong preference for the provision of information about hydrogen in the focus groups. In this regard a section of the survey is devoted to the use of a quiz/hydrogen information sheet to test for the effects of knowledge, preferences, WTP and attitudes toward hydrogen adoption. By testing which factors influence early adoption the work can contribute more broadly to an understanding of preferences by early adopters in an island setting towards hydrogen end-use technologies in the transport sector.

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