Work package 6 - Deliverable 9

AcceptH2 Full Analysis Report

Comparative Analysis of the Impact of the Hydrogen Bus Trials on Public Awareness, Attitudes and Preferences: a Comparative Study of Four Cities

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SUMMARY

This report presents the main findings from the four AcceptH2 economic valuation studies carried out in Berlin, London, Luxembourg and Perth, *after* the introduction of hydrogen (H2) bus trials in each of the cities, and compares these ex post results to findings from similar studies carried out about 1 year earlier *before* the bus trials. These studies used survey-based methods to investigate public knowledge, perceptions and attitudes towards hydrogen fuel cell buses, and estimate willingness to pay (WTP) for the environmental benefits (air and noise pollution reductions) of the large-scale introduction of hydrogen buses in the associated cities. The study was directed primarily at bus users in each city, although a number of non-bus users were also interviewed in London and Perth (Berlin, Oakland and Luxembourg samples only bus users). Comparative analysis of the ex ante and ex post survey data allows for the identification of changes in public knowledge, attitudes and WTP associated with these buses, and an assessment of the relative influence of the bus trials on these factors.

Results indicate that awareness of hydrogen vehicles *prior* to the bus trial was highest amongst Berlin respondents (73% of bus users had heard about hydrogen vehicles) and lowest amongst London respondents (47% of bus users and 38% of non bus users had heard of H2 vehicles). The higher initial awareness levels in Berlin are probably due to the fact that there had already been another H2 bus trial in the year 2000, and a number of other H2 vehicle trials during the 1980's. Regression analysis indicates that six months into the bus trials, awareness levels in Berlin and London have not changed significantly, whereas there has been a statistically significant increase in public awareness of H2 vehicles in Luxembourg and Perth.

Furthermore, ex post survey respondents in Perth and Luxembourg are the most aware about the H2 bus trials taking place in their city: 59% of bus users and 54% of non-bus users in Perth have heard about the trials, and 51% of Luxembourg bus users have heard of them. Conversely, in London, only a 20% of bus users and 15% of non-bus users were aware that these trials were taking place. These results suggest that the trials have had a higher impact on public awareness in Luxembourg and Perth, whilst the other bus trials have been less successful in this respect (however, Berlin bus users

were initially the most informed, so the potential for increase was not as significant as for London and additionally, their bus trial involved just one H2 bus operating for about 6 months).

Although it is evident that three H2 buses will be more visible in smaller cities such as Perth, compared to larger cities such as London, it is suggested that the different levels of influence of the H2 bus trials on bus user awareness in each city also reflects the extent of public outreach and information campaigns that accompanied these demonstration projects. In Perth, in particular, there has been an extensive public dissemination campaign associated with this trial, involving brochures, school visits, TV programmes, a dedicated website, conferences and various radio interviews. Luxembourg also made radio commercials when the buses arrived, and more than 1,000 persons took part in dedicated guided tours during the first six months of the Luxembourg bus trial alone. In contrast, in London only a handful of articles about the bus trials were published in the media; in Berlin, as noted, the trial involved one bus only operating for about 6 months, and very limited media attention.

Unconditional support for the large-scale introduction of H2 buses was significantly higher in every city 6 months after the H2 bus trials had begun; prior knowledge about hydrogen was a major driver for support in Berlin, Luxembourg and Perth. The increase in support in Luxembourg and Perth may be a result of the increased levels of knowledge about H2 vehicles, noted earlier. However, given that knowledge levels in Berlin and London have not increased, this attitude change is likely to be due to other related factors, such as increased concerns about climate change and air pollution impacts. In London, for example, there have been a number of television programmes and newspaper articles about climate change over the past year; it is possible that this information has influenced attitudes towards new environmental technologies, such that respondents are more likely to express unconditional support despite no prior knowledge about this particular technology.

However, increased unconditional support is not matched by increased willingness to pay for the large-scale introduction of H2 buses in most cases. Estimated WTP extra bus fare from the ex ante survey is not significantly different to that from the ex post survey (average of €0.35 for bus users in all cities). WTP taxes has also remained

stable in most cases, except in Luxembourg, where ex post WTP taxes have increased significantly independent of all socio-economic and attitudinal variables included in the regression. Additionally, there has been an increase in WTP taxes amongst all respondents in the Perth sample, but this is only significant at the 10% level. Thus it appears that, although attitudes towards H2 buses have become more positive in all cases, preferences have not changed much overall.

Finally, it is interesting to note that direct experience of H2 buses appears to have no effect on attitudes towards or preferences for H2 buses in any of the cities. Furthermore, respondents interviewed on-board H2 buses in Luxembourg appear to be less likely to unconditionally support the large-scale introduction of H2 buses in Luxembourg, and more likely to say that their support depends on the outcome of the trials. Additionally, on-board respondents in Luxembourg and Berlin are WTP significantly less in extra taxes to support the introduction of H2 buses, compared to all other ex post respondents, although their WTP extra bus fare is not significantly different. Thus, it is suggested that taxes might not be suited to finance the introduction of H2 powered buses in Luxembourg and Berlin.

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ABBREVIATIONS AND ACRONYMS

Acronym	Description
AcceptH2	Public Acceptance of Hydrogen Transport Technologies (project acronym)
CUTE	Clean Urban Transport for Europe
CV	Contingent Valuation
FC	Fuel Cell
H2	Hydrogen
H2-ICE	Hydrogen Internal Combustion Engine
ICE	Internal Combustion Engine
WTP	Willingness to Pay

1. INTRODUCTION

The development of both hydrogen (H2) fuel cell (FC) vehicles and H2 internal combustion vehicles is approaching the stage where public perceptions and acceptance of these new technologies will be critical to their success. While there is strong industrial and political interest in the introduction of hydrogen vehicles to the market, a belief among many experts persists that the wider public would not accept hydrogen fuel for safety reasons.

Despite these concerns about the public reaction to hydrogen technologies, only a handful of studies have investigated public acceptability for H2 vehicles (e.g. Altmann and Graesel, 1998; Dinse, 1999; Lossen, 2003). Findings from these studies indicate that at present, the public is generally positive about hydrogen-fuelled vehicles despite very low awareness levels. Furthermore, only one study to date has assessed economic preferences associated with H2 fuel cell (FC) vehicles, namely the study by Mourato et al (2004) which investigates taxi-driver preferences for H2 FC taxis. This study showed that safety was not a concern amongst taxi drivers, and that overall, they were willing to pay extra to have H2-fuelled FC taxis. A comprehensive review of studies associated with H2 acceptability and preferences can be found in the public area of the project website (Deliverable 3, Work Package 3).

Using survey-based methods for data collection, the AcceptH2 project aims to clarify this question significantly. As explained in the project description, the AcceptH2 study is a cross-continental comparative assessment of public knowledge, acceptability and preferences ('willingness to pay') for H2-fuelled buses, in five cities: Berlin (Germany), London (UK), Luxembourg, Oakland (US) and Perth (Western Australia). Surveys were administered to bus users – and in some cases, non-bus users too - *before* the introduction of H2 buses in each of these cities; a second round of surveys was also administered *after* the introduction of H2 buses in Berlin, London, Luxembourg and Perth. Oakland did not carry out an ex post survey. A comprehensive analysis of the ex ante survey data can be found in the public area of the project website (Deliverable 6, Work Package 6).

This report presents results of the *ex post surveys* and compares results, where relevant, to the ex ante survey findings. The aim of this report is to assess the influence of each of the H2 bus demonstration projects on public awareness, acceptability and preferences. Thus, the analysis firstly assesses whether there have been statistically significant changes in public awareness, acceptability and preferences for hydrogen buses, over the 1-year period between the ex ante and ex post surveys. Any identified changes in these factors are then interpreted in the light of all possible influences, including the influence of the H2 bus trials. Likewise, a lack of identified change in awareness, attitudes and preferences must also be interpreted in the light of all possible influences.

This study is mostly concerned with bus user attitudes and preferences; however, the London and Perth surveys also captured a significant proportion of non-bus users, in order to explore acceptability and preferences of the whole population in these cities. Analysis of the full population data for London and Perth shall therefore be explored briefly at the end of this report. Oakland did not perform an ex post survey, and the ex ante survey structure is very different from that used in Berlin, London, Luxembourg and Perth; thus, the Oakland ex ante analysis has been presented as an annex to the ex ante comparative analysis (Deliverable 6).

The rest of this report is structured as follows: the next section describes the survey design and data collection process; Section 3 presents comparative descriptive statistics of the bus user samples in each city; Section 4 presents summary statistics of bus user preferences for the large-scale introduction of H2 buses in each city, and Section 5 contains the econometric analysis of the determinants of 1) prior knowledge about hydrogen, 2) unconditional support for H2 buses and 3) preferences for the large-scale introduction of H2 buses in each city. Section 6 then addresses the attitudes and preferences of the whole London and Perth samples (including non-bus users), analysing mean willingness to pay (WTP) and determinants of this. Finally, Section 7 presents the conclusions.

2. SURVEY DESIGN AND DATA COLLECTION

2.1 Survey Design

In order to measure public perceptions, knowledge, attitudes and preferences associated with the potential introduction of H2 FC bus transport in each demonstration city, a contingent valuation survey was used (Mitchell and Carson, 1989; Bateman et al, 2002). CV methods were developed within environmental economics as a means to place an economic value on environmental changes, which due to their public good nature, are not traded in the market. The method involves a questionnaire in which respondents are presented with a hypothetical (or 'contingent') market where the good or service in question can be traded. Respondents are then typically asked for their willingness to pay (WTP) for a hypothetical change in the level of provision of the good or service. Contingent valuation assumes that stated WTP is a measure of respondents' underlying preferences, and is equivalent to the Hicksian welfare measures (Mitchell and Carson, 1989).

A series of three focus groups and a pilot study were held in London during June 2003 to assist in the design of the pilot study and the final questionnaires (the report can be found on the project website). The *ex ante questionnaire,* administered to respondents in Berlin, London, Luxembourg and Perth *before* the trial of the H2 buses in each city, involved an extensive questionnaire aimed at identifying knowledge and perceptions about hydrogen-fuelled transport, and attitudes and preferences associated with the introduction of H2 FC buses in each of the study-cities. The *ex ante questionnaire* used in Oakland was substantially shorter, and did not include any valuation questions.

The *ex post questionnaire*, carried out in Berlin, London, Luxembourg and Perth after the H2 buses had been running for about 6 months, was adapted from the longer ex ante questionnaire and streamlined to make it shorter. Oakland did not carry out an ex post survey. In addition, Berlin and Luxembourg carried out small samples of interviews with respondents on-board the H2 buses. The full version of all these questionnaires can be found in the member's area of the project website.

All of the questionnaires (ex ante *and* ex post) established: bus usage, attitudes towards existing buses in each city (except in the Perth ex post survey, and the on-board survey), spontaneous associations with the word 'hydrogen', knowledge about H2 FC vehicles (except in the ex post on-board survey), and attitudes towards the potential large-scale introduction of H2 buses in each city.

Respondents were then presented with neutral and balanced information on the advantages and disadvantages of H2 as a fuel for transport, and a brief description of the CUTE, Berlin, STEP or AC Transit H2 bus projects. After giving respondents this information, attitudes towards the trial and large-scale introduction of H2 buses in each city were explored again. Respondents who were interviewed on-board the H2 buses were also asked to rate several features of these buses in comparison to conventional diesel buses.

The valuation section of the questionnaires administered in Berlin, London, Luxembourg and Perth presented respondents with the following scenario of large-scale introduction of H2 buses in their city: "*Suppose that there was a proposal to substitute the buses in the [city] transport system for hydrogen fuel cell buses. As I mentioned earlier, these hydrogen buses would emit zero air pollution, be less noisy and more efficient than conventional buses. However they would also be more costly to run"*. Willingness to pay for the large-scale introduction of H2 buses in each city was elicited using two different payment vehicles. The first (WTP_S) involved willingness to pay extra on top of a standard single bus fare. The second mechanism (WTP_X) involved annual increases in taxes (tax type not specified). The elicitation format used was a payment ladder. This involves asking respondents to choose a WTP amount from a series of amounts read out by the interviewer, starting at zero and increasing by discrete amounts to a maximum. Figure 1 shows an example of the WTP_S payment ladder used in the London survey.

Figure 1: Example of payment ladder used in London surveys

"A single bus fare costs 1 pound. How much more would you be willing to pay per fare to have hydrogen fuel cell buses introduced in London on a large scale?"

TICK ONE ONLY:

0	
2 pence	
5 pence	
10 pence	
15 pence	
20 pence	
30 pence	
50 pence	
75 pence	
£1	
£2	
£3	
£4	
£5	
Other amount (Specify)	…….

Finally, the questionnaires also elicited information on socio-economic characteristics (e.g. age, income) and general environmental attitudes, knowledge and behaviour.

2.2 Data Collection

The *ex ante surveys* were conducted with residents of Berlin, London, Luxembourg and Perth between July 2003 and February 2004, and with residents in Oakland between May and June 2005. The Berlin, Luxembourg and Oakland surveys were conducted only with bus users, whilst the London and Perth samples included non-bus users too. The *ex post* surveys were carried out approximately one year later only in Berlin, London, Luxembourg and Perth, between July 2004 and February 2005. As noted earlier, Oakland did not carry out an ex post study. Table 1 summarises the data collection and briefly describes the samples for each city.

Table 1: Summary of data collection

	Berlin	London	Luxembourg	Oakland	Perth
Ex ante survey					
Total sample size	344	414	300	302	300
No. bus users	344	306	300	302	147
% bus users	100%	74%	100%	100%	49%
Ex post survey					
Total sample size	263 (a)	300	301 (b)	-	300
No. bus users	263	249	301	-	165
% bus users	100%	83%	100%	-	55%
Ex post survey sub samples					
No. first-time interviewees	47	223	157	-	300
% first-time respondents	18%	74%	52%	-	100%
No. repeat interviewees	146	77	97	-	-
% repeat interviewees	55%	26%	32%	-	-
No. on-board H2 bus interviewees	70	-	47	-	-
% on-board H2 bus intervs	27%	-	16%	-	-

(a) One respondent was dropped from the analysis as she was under 18
(b) Two respondents under 18 years old were dropped from analysis

As can be seen in Table 1, the ex post survey samples in most of the cities consist of various sub samples: in Berlin, over half (55.5%) of the total ex post sample consists of 'repeat' respondents; these are individuals who completed the ex ante survey one year earlier, and who had agreed to be contacted in the future for another interview. In London and Luxembourg repeat respondents make up smaller proportions of the overall sample size (25.7% and 32% respectively), whereas in Perth there were no repeat interviews. In addition, a number of people on-board the H2 buses were interviewed in Berlin and Luxembourg, making up 27% and 16% of the total ex post survey samples. On-board respondents were not interviewed in London and Perth. The rest of the surveys consisted of randomly selected respondents (see below for description of random selection process).

All the *ex ante questionnaires* in Berlin, London, Luxembourg and Perth were carried out by telephone, using randomly selected telephone numbers (Berlin, Luxembourg and Perth used numbers selected randomly from the telephone directory, whilst the London survey used telephone numbers generated randomly using Excel software). Each survey took between 2 and 3 months to complete, and the average duration was about 25 minutes per interview. In London, 6 questionnaires were dropped from the final analysis due to incompletion and in Berlin, one questionnaire was dropped due to incompletion. The Oakland *ex ante* survey however, involved self-completion questionnaires that were distributed at bus stops in the Oakland area. Interviewers were always available to answer any questions, and assist in the completion of these questionnaires where necessary. Each survey took about 10-15 minutes to complete.

Ex post questionnaires with randomly selected respondents, who were *not* on-board the H2 buses, were carried out by telephone using the same random telephone number selection approaches as described above. Repeat interviews were also carried out by telephone using telephone numbers from the ex ante survey. The average duration per telephone questionnaire was about 10-15 minutes per interview, which is substantially shorter than the duration of the ex ante interviews. On-board interviews were carried out by handing out questionnaires and pencils to people getting on-board the H2 buses, and collecting the completed questionnaires as they left the bus.

3. BUS USERS: DESCRIPTIVE ANALYSIS

As noted, given that this study is mostly concerned with bus user attitudes and preferences towards H2 buses, the analysis presented in this report will focus mostly on bus users. Thus the following section presents the ex post survey results, and carries out a comparative ex ante/ ex post analysis of bus user awareness, acceptability and preferences associated with H2 vehicles and buses in Berlin, London, Luxembourg and Perth.

3.1 Socio-economic Characteristics

Table 2 presents socio-economic characteristics of the *ex post bus user samples* from each city. Overall, results indicate that the samples from each city have very different socio-economic characteristics. For example, Berlin has a significantly higher proportion of males compared to the other cities. Education levels are also very different between samples: almost three fifths (57%) of the London bus user sample has a university degree compared to just under a third (29.8%) of the Berlin sample with similar qualifications. Perhaps most notably however, is the significant discrepancy between income levels. As figures show, average income levels (in Euros) for the London bus user sample are about double the Berlin average income, and 20,000€ above the next highest income (in Luxembourg).

Due to a lack of sufficient data on the characteristics of bus user populations in each city, it has not been possible to weight the data accordingly[1]. Therefore generalisations of the un-weighted sample results to the overall city bus user populations should be interpreted with caution.

Table 3 compares the ex ante and ex post bus user samples for each city. As can be observed, there are quite a number of statistically significant differences between the ex ante and ex post samples, especially in Berlin where the ex post sample consists of significantly younger employed males (all significant at the 1% level) with cars (significant at the 5% level). This difference between the ex ante and ex post samples for Berlin might be attributed to the different data collection processes in the ex ante survey (random telephone dialling) compared to the ex post survey (i.e. on-board and repeat telephone interviews, as well as random dialling). However, in Perth – and in London to a large extent - the ex post surveys were administered using the same random telephone approach as in the ex ante survey, and yet the samples differ significantly on several fronts. This is likely to be associated with the small sample sizes used in this study; it is expected that random recruitment processes such as random telephone dialling would produce samples with statistically similar characteristics for larger sample sizes.

[1] It is considered that comparisons of the bus user samples with the general populations of each city is inappropriate as there is no reason to assume that bus users have the same characteristics as non-bus users.

Table 2: Socio-demographic characteristics of *bus users* (ex post)

Variable	Levels	Berlin Bus User Sample (n=263)	London Bus User Sample (n=249)	Luxemburg Bus User Sample (n=301)	Perth Bus User Sample (n=166)
Sex (% male)		52.5 **/^^^/†††	45.4 ^^	37.5	41.0
Age (mean) (a)		45 ***/^^	38.8 ^^^/†††	47.4	46.1
Highest level of education (% respondents)	Primary/ no qualification	21.3 ***/††	12.3 ^^^/†††	22.6	29.7
	University degree	29.8 ***/^/††	57.0 ^^^/†††	35.4	36.7
Work Status (% respondents)	Self-employed	8.85	7.23	4.68	7.83
	Employed (>30 hrs/wk)	39.6	67.9	40.5 ††	30.12
	Employed (<30 hrs/wk)	9.23	5.22	10.5	15.7
Gross annual household income (mean) (a)		34,349€	£48,767	49,569€	AU$49,917
Gross annual household income (mean in Euros) (b)		34,349 ***/^^^	70,677 ^^^/†††	49,569 †††	29,890
Car ownership (% households owning car)		62.7	65.1 ^^/†††	77.5 †††	92.2
Respiratory illness in respondent's household (% respondents)		30.9 †††	31.3 †††	32.9 †††	41.0

* Significantly different to London at 10% level, ** at 5% level, *** at 1% level
^ Significantly different to Luxembourg at 10% level, ^^ at 5% level, ^^^ at 1% level
† Significantly different to Perth at 10% level, †† at 5% level, ††† at 1% level

(a) Income/age taken as mid-interval of income/age categories.
(b) Converted using http://www.xe.com/ucc/convert.cgi on April 20th 2005 (exchange rate of £0.69 and AU$1.67 to 1€).

Table 3: Comparing key socio-economic characteristics of ex ante and ex post survey bus user samples for each city (a)

	Ex ante	Ex post	t-test probability
Berlin	(n=345)	(n=263) (b)	
Sex (% male)	44.0	52.5	0.005 ***
Age (mean)	50.9	45.0	0.000 ***
University education (% respondents)	26.2	29.8	0.203
Employed (% respondents)	37.0	57.7	0.000 ***
Gross annual household income (mean €)	31,598	34,349	0.325
Car ownership (% households)	56.4	62.7	0.037 **
London	(n=308)	(n=249)	
Sex (% male)	41.9	45.4	0.272
Age (mean)	37.6	38.8	0.196
University education (% respondents)	49.7	57.0	0.021 **
Employed (% respondents)	79.8	80.4	0.954
Gross annual household income (mean £) (a)	41,272	48,767	0.001 ***
Car ownership (% households)	61.4	65.1	0.228
Luxembourg	(n=300)	(n=301) (a)	
Sex (% male)	35.7	37.5	0.531
Age (mean)	45.8	47.4	0.115
University education (% respondents)	32.7	35.4	0.350
Employed (% respondents)	59.1	55.9	0.275
Gross annual household income (mean €)	39,124	49,569	0.000 ***
Car ownership (% households)	82.0	77.5	0.065 *
Perth	(n=146)	(n=166)	
Sex (% male)	43.2	41.0	0.560
Age (mean) (a)	41.2	46.1	0.000 ***
University education (% respondents)	43.8	36.7	0.062 *
Employed (% respondents)	61.6	53.6	0.041 **
Gross annual household income (mean AU$)	54,205	49,917	0.088 *
Car ownership (% households)	89.0	92.2	0.132

(a) Respiratory illness was not elicited in the *ex ante* survey, hence comparisons cannot be made in this table between ex ante and ex post levels of respiratory illness in respondents' households.
(b) Samples described in this table include first-time, repeat and on-board respondents (all bus users)

As observed above, due to a lack of sufficient data on the characteristics of bus user populations in each city, the data has not been weighted accordingly. As a

consequence of this lack of weighting, the ex ante and ex post samples are not strictly comparable. Therefore, any comparisons between the descriptive statistics for the ex ante and ex post bus user samples (in the following sections) must be made with caution by taking into account the different socio-economic characteristics of the ex ante and ex post samples.

The measurement of statistically significant differences between public knowledge of, attitudes towards and willingness to pay for H2 buses of the ex ante and ex post samples will be carried out using econometric regression methods. These will be described in each relevant section when used.

3.2 Use of Existing Buses

Bus users (i.e. respondents who had used a bus at least once in the past 12 months) were asked to indicate how often they use the bus. In the *ex ante survey*, the Luxembourg sample had the highest proportion of regular bus users (68% used the bus at least once a week), followed closely by London (62% used the bus at least once a week). Berlin and Perth ex ante survey bus users use the bus less frequently: 55% and 42% of bus users in Berlin and Perth respectively used the bus at least once a week. However, London bus users used the bus more intensely with 54% taking the bus *at least* 5 times a week, whereas in Luxembourg 43% did so at least 5 times a week; only 29% of Berlin bus users and 28% of Perth bus users took the bus over five times a week in the ex ante survey.

In the *ex post survey,* similar proportions of bus users in Berlin, Luxembourg and London take the bus at least once a week (63%, 63% and 60% respectively) whereas in Perth only 31.5% of bus users use the bus at least once a week. However, as with the ex ante survey results, Londoners use the bus most often, with 38% of bus users using the bus *at least* 5 times a week, followed by Luxembourg (31.5% use the bus at least 5 times a week), Berlin (29.5%), and Perth (22%).

It appears that, overall, bus use is less frequent amongst ex post survey bus users in all the city samples. However, the relative positions of the different cities with regard to frequency of bus use are the same for both ex ante and ex post samples.

3.3 Attitudes towards Existing Buses

It is expected that attitudes towards and WTP for the introduction of H2 buses in each city will be influenced by respondents' perceptions of the existing buses in their respective cities. Thus, all bus users in the ex ante survey, and *only first-time and repeat bus users from the ex post surveys*, were asked to rate a number of features of their existing city buses using a scale from 1 to 5, where 1 is '*very poor'* and 5 is '*very good'*. Table 4 presents the mean ratings from the *ex post surveys* in Berlin, London and Luxembourg (the Perth ex post survey did not include this question).

Table 4: Mean rating of features of existing buses and air quality in city (ex post)

Characteristic	Berlin	London	Luxembourg	Totals
Frequency	3.53	3.47	3.90	3.63
Reliability	3.60	3.18	3.74	3.51
Number of bus stops	3.72	3.84	3.94	3.83
Bus fares	2.57	3.26	3.27	3.03
Crowding	3.28	2.76	3.36	3.13
Fumes from buses	3.24	2.58	3.34	3.05
Noise from buses	3.28	2.86	3.37	3.17
Average rating per city	3.32	3.14	3.56	-
Air quality in city	2.63	2.10	3.18	2.64

Results indicate that on average, the features of existing buses that ex post-survey respondents were most satisfied with were: "*number of bus stops", "frequency of buses"* and *"reliability"*. The least favoured attributes of existing buses were *"bus fares"* and *"fumes from buses"*.

On an individual city level, Luxembourg bus users appear to be the most satisfied with their buses (mean overall rating of bus features is 3.56) and London bus users are

the least satisfied (mean rating of 3.14). Notably, London respondents are particularly dissatisfied with fumes buses; this feature has the lowest rating of all the London bus features (mean rating of 2.58). Bus users in Berlin on the other hand are much less satisfied with *"bus fares"* (mean rating of 2.57), compared to bus users in London and Luxembourg (mean rating of 3.26 and 3.27 respectively). This is consistent with the cost of single bus fares in each city, since the fares in London (£1.00=1.45€) and Luxembourg (1.20€) are almost half of the fare in Berlin (2.20€).

Respondents to the ex post surveys were also asked to rate the air quality in each of their cities using the same scale as they used to rate the bus features (see above). Results, presented in the last row of Table 4, indicate that bus users are overall dissatisfied with the air quality in their respective cities. A mean rating of 2.64 indicates that overall, respondents rate this feature of their cities as below average; however, on an individual city level, Luxembourg bus users rate the air quality as above average, whereas London bus users rate the air quality as "*poor"* (mean of 2.10).

Given that the ex ante results to this question are quite similar to the ex post results, comparisons between ex ante and ex post attitudes towards existing buses shall be restricted to certain key features of relevance in this study: namely, "*fumes from buses", "bus fares" and "noise from buses"*. Thus Table 5 compares ex ante and ex post ratings associated with each of these features. The full set of results for this question from the *ex ante survey* can be found in the ex ante comparative report (Deliverable 6, Work Package 6).

Table 5: Comparing ex ante and ex post mean ratings of features of existing buses in Berlin, London and Luxembourg

Characteristic	Berlin		London		Luxembourg	
	Ex ante	**Ex post**	**Ex ante**	**Ex post**	**Ex ante**	**Ex post**
Bus fares	2.40	2.57 ***	3.52	3.26 ***	3.52	3.27 **
Fumes from buses	3.24	3.24	2.50	2.58	3.36	3.34
Noise from buses	3.28	3.28	2.72	2.86 **	3.40	3.37
City average (ALL features)	3.36	3.32	3.02	3.14 *	3.68	3.56 *

Results indicate that attitudes towards bus fares have changed significantly in every case: the ex post sample rates bus fares more positively than the ex ante sample in Berlin, whereas the inverse is true of London and Luxembourg. In London this is likely to be a result of the increase in bus fares from 70 pence to £1 (GLA, 2002) that occurred during the 1-year period between ex ante and ex post surveys.

3.4 Environmental Attitudes, Knowledge and Behaviour

It is also expected that environmental attitudes will influence attitudes towards and willingness to pay for hydrogen buses. Therefore, environmental attitudes were elicited in every city by asking respondents to indicate their level of agreement with a number of statements using a scale from 1 to 5, where 1 indicates '*strongly disagree'* and 5 indicates *'strongly agree'*. As with results to attitudes towards bus features, this section shall present only the *ex post survey* results, whilst highlighting any major differences in environmental attitudes between ex ante and ex post respondents. Mean results for bus users are shown in Table 6[2].

Results indicate widespread agreement that "*solving environmental problems should be one of the top 3 priorities for public spending"*. However, bus users in Perth and London are less inclined than Berlin and Luxembourg respondents to agree that: *"it is necessary for everyone to give up certain activities in order to protect the environment"*. Notably, there is a general ambivalence about the role of science and technology in solving environmental problems, evidenced by an average value of 3.5 (indicating that respondents situate themselves between "*neither agree nor disagree"* and *"agree"*). Overall, Berlin and Luxembourg respondents show the strongest environmental attitudes, whilst Perth and London show the weakest environmental attitudes.

Environmental knowledge associated with climate change is weak, as indicated by the mean response to the statement *"The main cause of global warming is the hole in the ozone layer"*. Knowledge about the relationship between car use and urban air

[2] Attitudes of non-bus users will be presented in Section 6 where knowledge, attitudes and WTP of the whole London and Perth samples are analysed.

pollution is marginally greater however. These results are very similar to those amongst bus users in the ex ante survey (see ex ante comparative report for full results for these statements from the ex ante survey).

Table 6: Mean environmental attitudes and knowledge (*bus users only*)

Item	Berlin (a)	London (a)	Luxembourg (a)	Perth
Environmental Attitude Statements				
1. Solving environmental problems should be one of the top 3 priorities for public spending in [city]	3.95	3.93	4.0	4.02
2. It is necessary for everyone to give up certain activities in order to protect the environment	4.15	3.88	4.1	3.72
3. The decline in world oil supplies is a major problem that will cause petrol prices to rise significantly in the next few years.	3.29	3.89	3.4	3.84
4. Environmental problems, such as global warming and air pollution have been over exaggerated	2.72	2.19	2.8	2.23
5. Science and technology are the key to solving environmental problems in [city]	3.6	3.47	3.6	3.49
Environmental Knowledge Items				
1. The main cause of global warming is the hole in the ozone layer	3.22	3.00	3.5	3.11
2. Car use is the main cause of air pollution in cities	3.7	3.56	3.6	3.44

(a) Mean values reported for both first-time, repeat *and* on-board respondents.

Respondents were also asked about their environmental behaviours. Table 7 shows the proportion of respondents who answered '*yes*' to the environmental behaviour questions.

Table 7: Percentage of respondents with environmental behaviours (*bus users only*)

Questions	Berlin	London	Luxembourg	Perth
1. Are you a member of, or have you donated to an environmental, conservation or wildlife organisation in the past 12 months?	19.6	28.0	26.5	32.7
2. When shopping, do you usually select one product over another due to environmental reasons (e.g. packaging/ ingredients)?	63.2	52.3	67.6	27.3

As can be seen in Table 7, environmental behaviours vary quite a lot across cities. Overall, however, Luxembourg bus user respondents appear to perform the most environmental behaviours.

3.5 Associations with "Hydrogen"

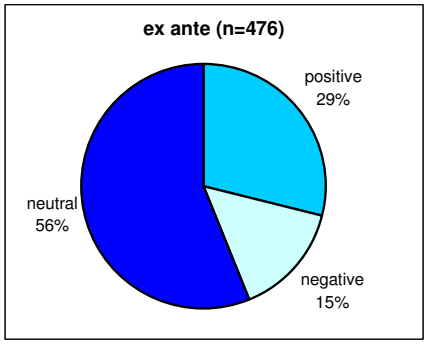
All respondents were asked: "*Please tell me the first words that occur to you when I say the word 'hydrogen'?"* Overall, at least two thirds of all respondents were able to provide at least one association with 'hydrogen', although Luxembourg respondents were the least able to provide any associations, with exactly 29% of respondents unable to provide an association in both ex ante and ex post surveys. London respondents were the most able to provide associations, with 10% in the ex ante survey and 3% in the ex post survey unable to provide an association with 'hydrogen'. Associations were coded individually, and then grouped under various broad headings (see Figure 2). Note that the distribution of associations presented in Figure 2 includes ALL respondents (including non-bus users), as there was no significant difference between associations made by bus users and non-bus users (in London and Perth).

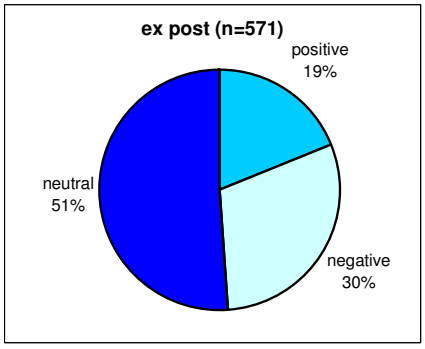
As Figure 2 shows, neutral associations (e.g. 'gas', 'peroxide', 'fuel') make up the greatest proportion of associations in every city; however, in what regards positive associations (e.g. 'clean', 'environmental') versus negative associations (e.g. 'explosion', 'Hindenburg'), there appears to be no consistent pattern. For example, ex ante survey results show that in London and Luxembourg, positive associations outnumber negative ones, although in London the difference is only marginal[3]. In Berlin and Perth however, negative associations outnumber positive ones in the ex ante survey. This situation is seen to change quite significantly for Berlin, where ex post results indicate that negative associations now significantly (at 5% level) outnumber positive ones. The distribution of associations in the other cities has is quite similar in the other cities.

[3] Note that the analysis of ex ante associations for the London sample presented in this report is a correction on the results that were presented in the ex ante comparative report, which were erroneous (Deliverable 6, Work Package 6).

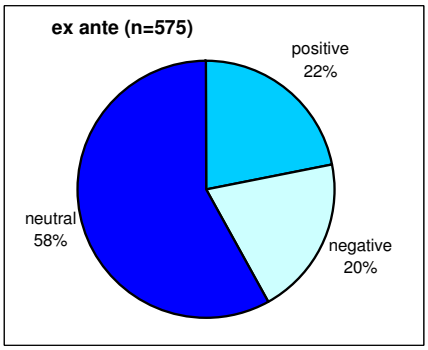
Figure 2: Distribution of total number of associations with the word 'hydrogen' per city

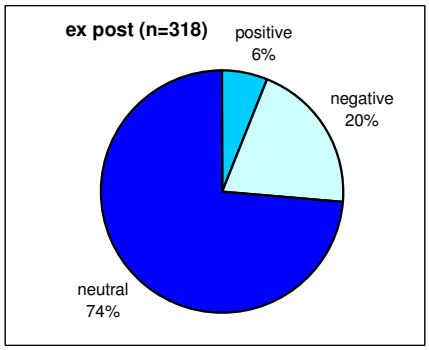
BERLIN



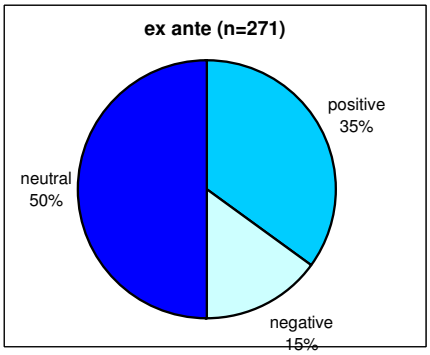


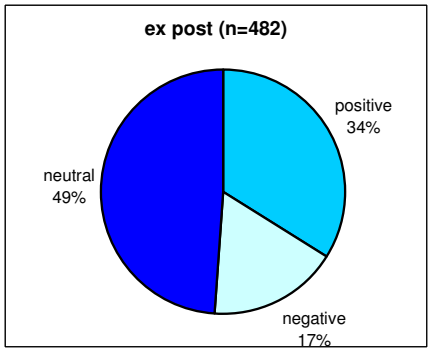
LONDON



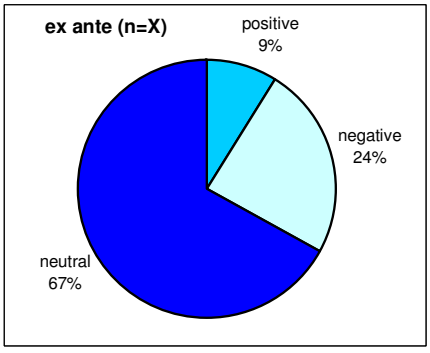


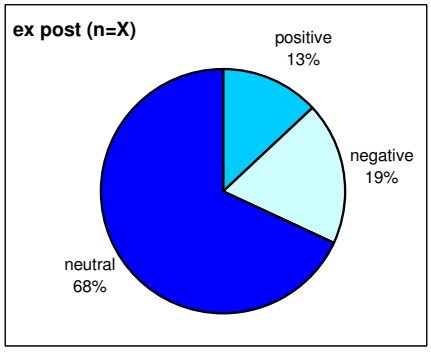
LUXEMBOURG





PERTH





Relationships between the type of H2 association made and an individual's socio-economic characteristics were investigated for the ex ante samples in Berlin, London and Luxembourg, in order to identify common perceptions across different socio-economic groups. In Berlin and London, significant relationships were found between gender and type of association made with hydrogen: in Berlin men gave more positive answers than women (Chi2 of 0.142, p= 0.055). However, in London, men gave marginally more negative associations with hydrogen than women, which stands in contrast to existing findings (Dinse, 2000).[4] On the other hand, men also gave more positive associations than women. Factor analysis was also attempted on the Berlin, London and Luxembourg ex ante samples to try to group respondents according to whether they gave two positive associations, two negative associations, two neutral associations, or a mix. No patterns were identified.

3.6 Knowledge about Hydrogen Vehicles

Prior to being given information about hydrogen and fuel cells, respondents to both ex ante and ex post surveys were asked: "*Did you know that car companies are developing hydrogen-powered [fuel cell] vehicles?"* In the ex post survey, this question was posed to randomly selected respondents as well as repeat interviewees; respondents interviewed on-board a H2 bus were not asked this question. Given that we are primarily interested in investigating levels of public knowledge about hydrogen *independent* of the influence of the ex ante survey on awareness, the results reported below are for randomly selected (first-time) respondents only. Furthermore, it is expected that repeat respondents will know about H2-powered vehicles simply as a consequence of having completed the ex ante survey. This assumption however, will be discussed in below.

Overall, self-reported awareness amongst *randomly selected* ex post survey bus users is higher than knowledge levels amongst ex ante bus users, with just over three fifths (62.9%) of all first-time ex post bus users claiming to have heard about hydrogen vehicles, compared to 57.3% of all ex ante bus users. In all cities, the main sources of information about H2-powered vehicles (ex ante and ex post) were newspapers/

[4] Dinse (2000) found that emotional and negative associations with hydrogen tended to be given by women.

magazines and television. Figure 3 shows the distribution of awareness levels for both ex ante an ex post survey bus user samples, and compares the percentages of respondents who said that they *had* heard about H2 vehicles in the ex ante and ex post surveys.

Figure 3: Comparing ex ante and ex post knowledge about H2 vehicles amongst bus users (first-time respondents not on-board a H2 bus only)

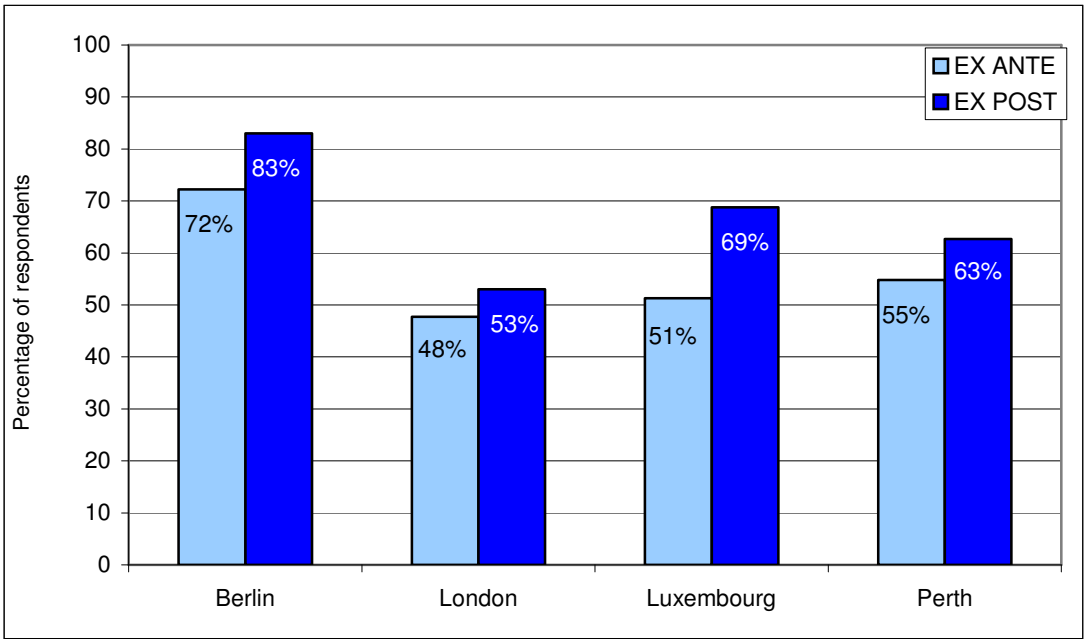


Figure 3 indicates that, in all four cities, ex post-survey bus users were more aware about the development of hydrogen vehicles than bus users in the ex ante samples. The greatest difference between ex ante and ex post-sample knowledge levels is found in Luxembourg, where 18% more ex post respondents were aware of the development of hydrogen vehicles. The smallest increase is found amongst the London bus user sample, with only 5% more ex post bus users having heard about H2 vehicles compared to ex ante bus users. In all the cities, the difference between ex ante and ex post knowledge levels is statistically significant, although in London and Perth, the difference is significant at the 10% level only.

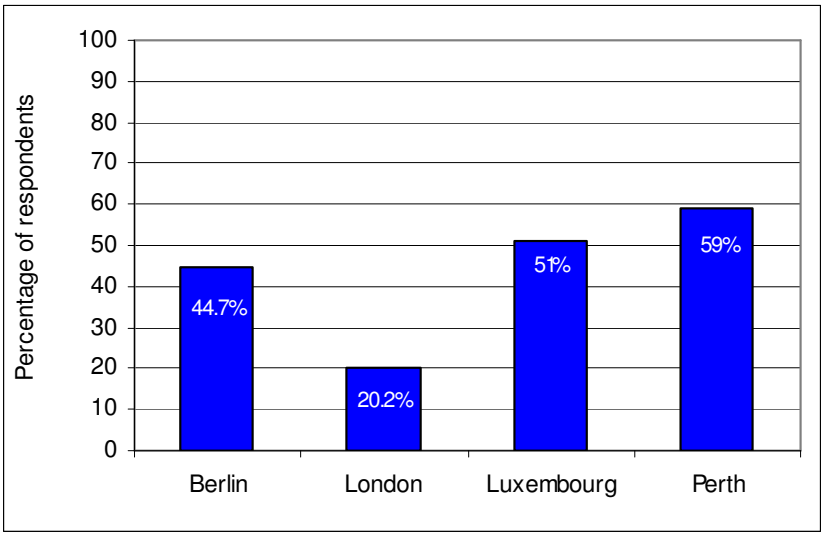
However, these results do not necessarily indicate that the bus user populations have become more knowledgeable. These differences could be attributable to the different socio-economic characteristics of the ex ante and ex post samples, as shown in Table 3. In order to determine whether the reported differences in knowledge levels are associated with a true increase in knowledge of the wider population, it is necessary to control for the varying socio-economic characteristics of the different samples. Therefore, a regression analysis has been carried out on the variable 'H2KNOW' (a dummy variable indicating whether a respondent has heard about H2-powered vehicles), using pooled data from the ex ante and ex post surveys for each city, to identify the determinants of knowledge. Socio-economic variables are included in the regressions, as well as a dummy variable representing the time of survey ('EXPOST'). If results of these regressions indicate that only the socio-economic variables are significant, then this suggests that there has been no true increase in knowledge in the wider population. However, if 'EXPOST' is significant, then this suggests that knowledge may have increased over time independent of the differences between samples.

Finally, it is worth noting that a number of repeat respondents did not know that car companies were developing hydrogen-powered vehicles. Specifically, 24%, 17% and 15% of respondents in Berlin, London and Luxembourg respectively, claimed not to know about this. This is very surprising given that they were informed of this fact when they completed the ex ante survey a year earlier. Such findings suggest that these respondents did not pay full attention to the information – or indeed any of the questions! – presented in the ex ante survey; this suggests that their answers may not be as reliable as one would hope.

3.7 Knowledge about Hydrogen Bus Trials

Ex post survey respondents were asked to indicate whether, prior to being informed in the survey, they knew that hydrogen buses had been running in their city for several months. Figure 4 shows the distribution of results for the randomly selected ex post bus user sample.

Figure 4: Knowledge about H2 bus trial amongst randomly selected ex post survey bus users

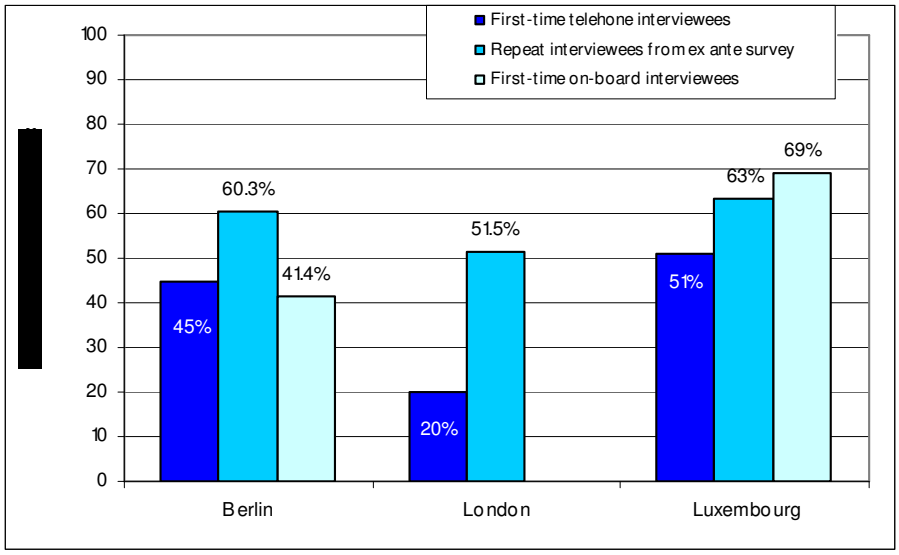


As Figure 4 shows, knowledge about the bus trials among randomly selected bus users is highest amongst the Perth bus user sample, followed closely by Luxembourg and Berlin samples. London bus users are significantly less likely (at the 1% level compared to all other cities) to have heard about the bus trials, with only a fifth of bus users in the sample having heard of the trials. Thus it is expected that the influence of the bus trials on knowledge and acceptability will be significantly lower in London, compared to the other cities. This will be investigated in the regression analyses in Section 5 of this report.

In London, the main sources of information about the bus trials were newspapers/magazines (27%), and direct contact with the H2 buses (14% had seen one and 14% had used one). In Perth the main source of information about the bus trials was visual contact with the H2 buses (33.5%), followed by TV (19%) and newspapers (15%). In Luxembourg, the main sources were TV (16%) and newspapers (26%), as is the case in Berlin: TV (29%) and Magazines (47%).

As with the analysis of respondent's knowledge about the development of H2-powered vehicles (previous section), repeat respondents are expected to be aware about the H2 bus trials because they were told about this during the ex ante survey. However, as results in Figure 5 show, awareness levels amongst this sub sample are surprisingly low[5].

Figure 5: Comparing knowledge about H2 bus trial amongst randomly, repeat and onboard ex post survey bus users



It is surprising to note, that awareness about the bus trials was remarkably low amongst repeat interviewees, with approximately 40% overall not remembering what had been explained to them in the ex ante surveys one year earlier. This suggests that, as noted earlier with reference to knowledge about H2 vehicles in general, these respondents did not pay full attention to the information presented in the ex ante survey. Alternatively, these results might indicate that, if initial information (such as that provided in the ex ante survey) is not followed up with additional information (e.g. a leaflet in the post, an advert, an article in a newspaper), individuals may simply forget this new information. This suggestion would require further research to be able to verify it.

[5] Perth ex post surveys did not include repeat or onboard respondents hence it was not included in Figure 5.

A small proportion of bus users in each city had actually travelled on one of the H2 buses[6]: 12 respondents in Berlin (4.5% of sample), 11 respondents in London (4.4% of bus user sample), 47 respondents in Luxembourg (19% of sample) and 15 respondents in Perth (9% of bus user sample). It is clear from these figures that Luxembourg respondents have had greater direct experience of the H2 FC buses being trialed in the city, as evidenced by the relatively high proportion of respondents who had used a H2 bus compared to the samples from other cities.

In London these respondents were sent a follow-up questionnaire to establish attitudes towards a number of features of the hydrogen buses. These results are presented in Section 3.11.

3.8 Attitude towards Hydrogen Buses

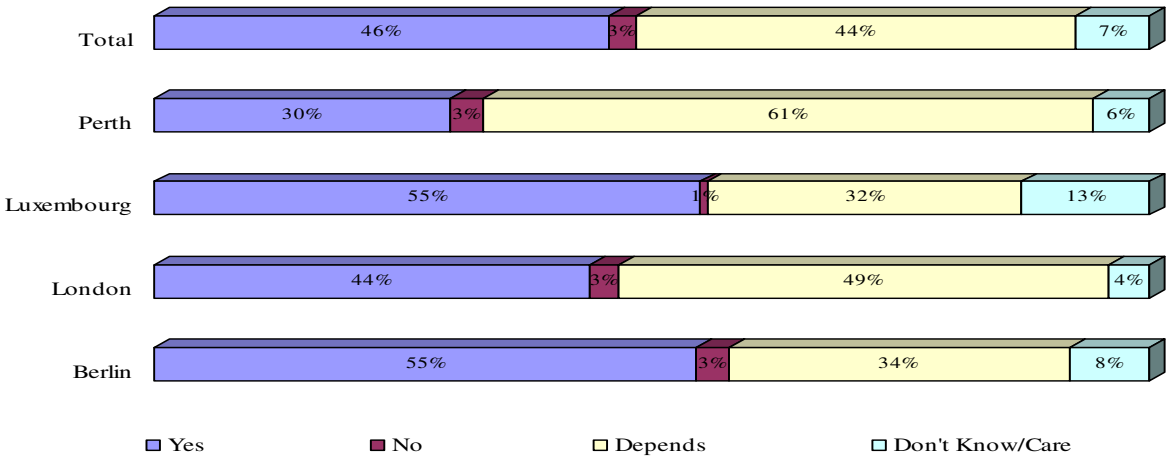
After being given information about hydrogen, fuel cells and the H2 bus trials, respondents were asked if they thought the H2 bus demonstration projects were a good idea. The rate of unconditional support – generally motivated by the potential environmental benefits – was overwhelming (90% overall) and opposition insignificant (about 1% overall). The differences between ex ante and ex post attitudes towards the bus trials are not significant and hence comparisons are not explored here.

Respondents however, were more cautious about the large-scale introduction of H2 buses in their cities. Figure 6 shows the distribution of answers to the question: *"Do you think it would be a good idea to introduce hydrogen (fuel cell) buses in [city] on a large-scale?*" As can be observed from the first two bar charts in Figure 6 (ex ante bus users and ex post first-time bus users), the overall level of unconditional support for the large-scale introduction of H2 buses is much higher (25% higher) amongst randomly selected ex post-survey respondents than among ex ante bus user respondents. The greatest difference in unconditional support levels between ex ante and randomly selected ex post samples is found in London, where ex post support levels are 28% higher than ex ante support levels. This is followed closely by Luxembourg, where ex post unconditional support is 26% higher.

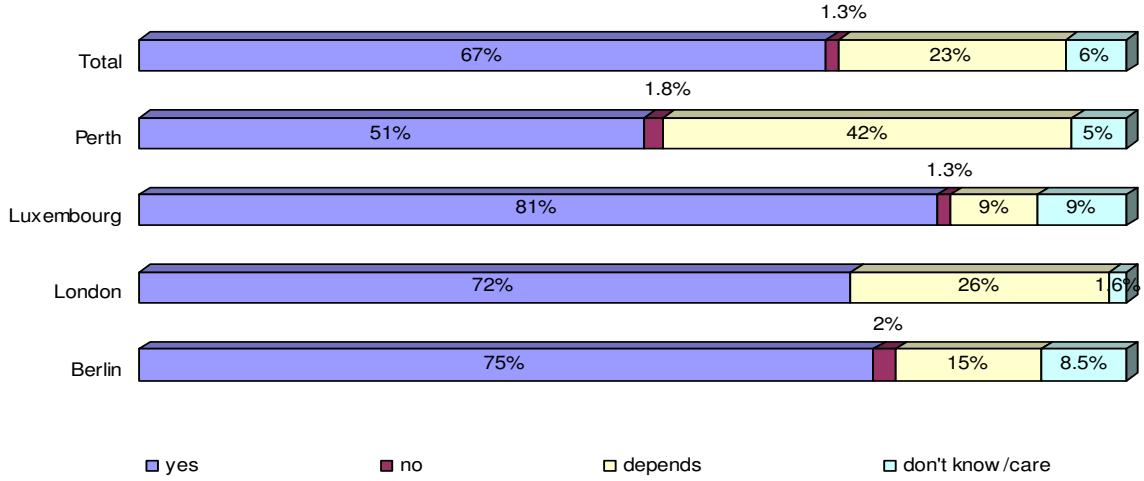
[6] These figures apply to bus users not on board the H2 buses.

Figure 6: Distribution of responses to the question: "*Do you think it would be a good idea to introduce H2 FC buses in [city] on a large scale?*"

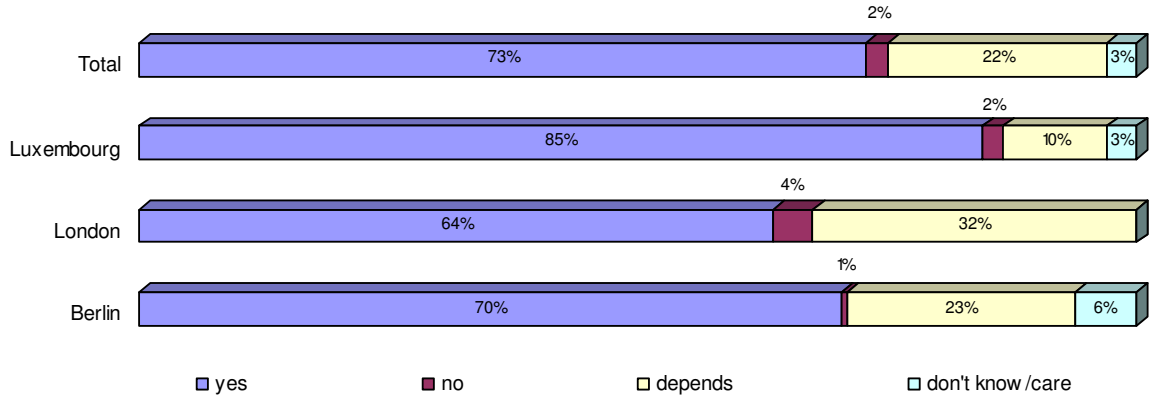
Ex ante



Ex post *random* respondents



Ex post *repeat* respondents from ex ante survey



Conditioned support (respondents who answered 'depends') is overall lower in the random ex post sample; in all cases support was conditioned on results of the trials and safety issues. It is perhaps worth noting that Perth bus users are less inclined to express unconditional support compared to respondents in the other cities; this suggests that Perth bus users are more cautious with regards to the introduction of H2 transport technologies. Finally, opposition levels are lower in the random ex post bus user samples; in London opposition in the ex post sample is non-existent.

The third bar chart in Figure 6 presents results for the sub sample of repeat ex post respondents (note: the Perth ex post survey did not include repeat respondents). In comparison to ex ante results, repeat respondents are unconditionally more supportive of H2 bus introduction in their respective cities. However, in contrast with random ex post respondents, London and Berlin repeat respondents are marginally less supportive. Furthermore, opposition to H2 buses is highest amongst repeat London bus users, although it is still low at about 4% of the sample opposing the introduction of H2 buses.

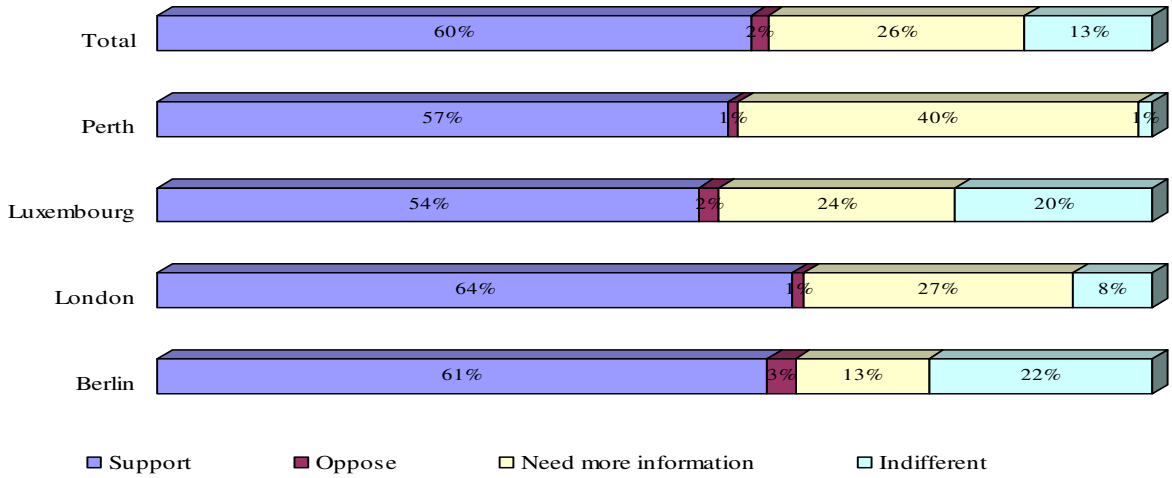
These findings clearly indicate that public attitudes are overall quite positive towards the large-scale introduction of H2 buses in all these cities, and unconditional support levels are higher amongst respondents interviewed 6 months into the H2 bus trials than amongst those interviewed prior to the bus trials. The question of whether these apparent increases in unconditional support levels have any statistical significance or whether they are attributable to the different socio-economic characteristics of the ex ante and ex post samples will be investigated using regression analyses.

3.9 Attitude towards Hydrogen Storage

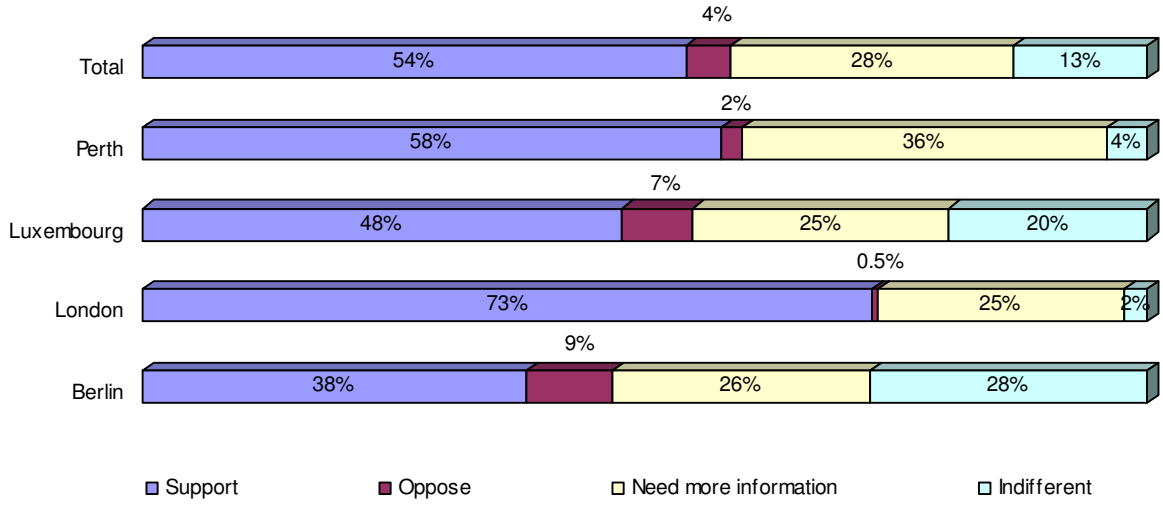
A favourable perception of hydrogen storage at local refuelling stations will be a crucial step towards setting up a hydrogen infrastructure for refuelling purposes. In order to assess respondent's attitudes in this respect, they were asked: *"How would you feel about having hydrogen stored and included as a fuel option at your local petrol station?"* Figure 7 shows the distribution of answers from all bus users in the ex ante and ex post samples (including repeat and randomly selected respondents).

Figure 7: Distribution of responses to the question *"How would you feel about hydrogen being stored and included as a fuel option at your local petrol station?"*

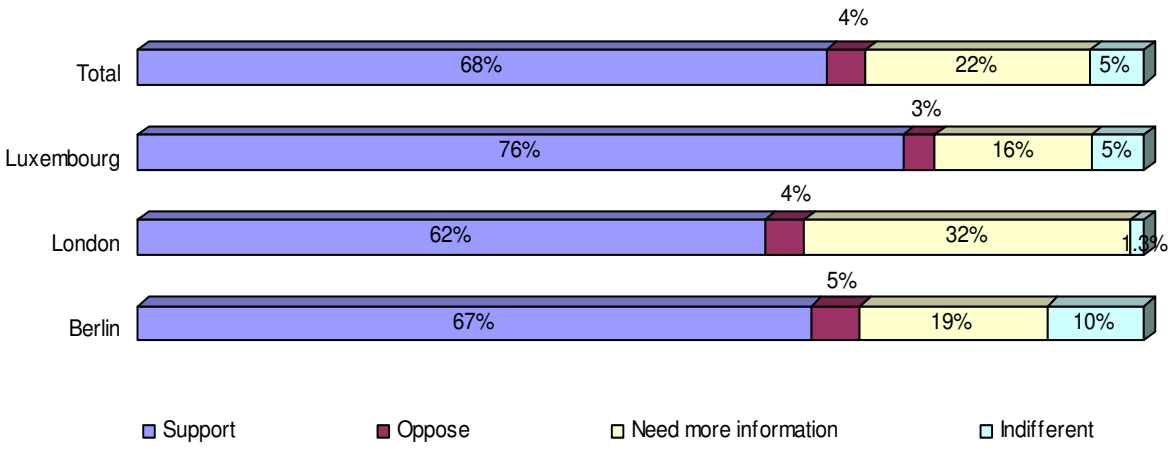
Ex ante



Ex post *random* respondents



Ex post *repeat* respondents from ex ante survey



As results show, attitudes towards the local storage of hydrogen fuel are largely positive overall, with over half of all bus users in all the city samples supporting these developments. The only exception is the random ex post sample from Berlin, where support levels among randomly selected bus users account for 38% of the sample. However, the random ex post values for Berlin must be interpreted with caution as they are based on a very small sample size of 47 respondents.

Support for local hydrogen storage is highest amongst London bus users in both the ex ante and random ex post samples. In addition, the random ex post sample for London has almost 10% higher support levels compared to the ex ante levels of support. However, amongst repeat respondents to the ex post survey, Luxembourg bus users are the most supportive (76%).

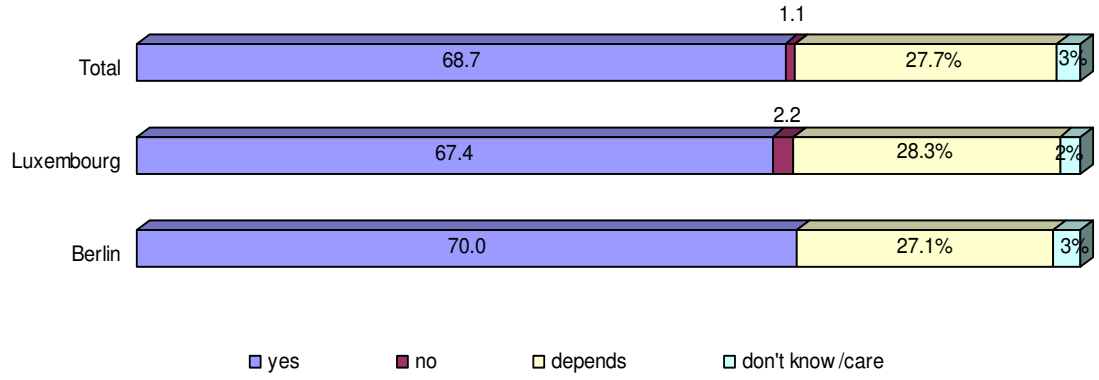
Opposition levels amongst random and repeat ex post respondents are higher than opposition levels in the ex ante samples. Notably, 9% and 7% of randomly selected bus users in the Berlin and Luxembourg ex post surveys respectively, oppose local hydrogen storage. Unfortunately the ex post survey did not explore the reasons for opposition.

3.10 On-board H2 bus respondent attitudes – Berlin and Luxembourg

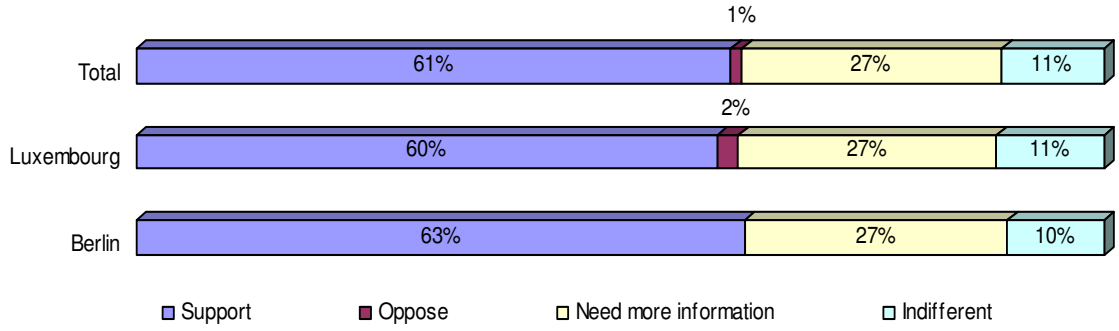
Small sub samples of ex post survey respondents were interviewed onboard the H2 buses in Berlin (n=70) and Luxembourg (n=47), in order to assess their attitudes towards hydrogen vehicles, as well as their attitudes towards the H2 buses that they were riding on. Figure 8 shows the distribution of attitudes towards the large-scale introduction of H2 buses in each city, and towards the storage of hydrogen fuel at respondent's local refuelling stations.

Figure 8: Attitudes of ex post respondents on-board a H2 bus

"Do you think it would be a good idea to introduce H2 FC buses in [city] on a large scale?"



"How would you feel about hydrogen being stored and included as a fuel option at your local petrol station?"



As results indicate, attitudes towards H2 buses and H2 storage are quite similar. However, if we contrast these results to the responses given by randomly selected and repeat respondents in Figures 6 and 7, it is apparent that Luxembourg on-board H2 bus respondents are less supportive than other ex post respondents. For example, 81% of random respondents and 85% of repeat respondents support the large-scale introduction of H2 buses, compared to 67% of on-board respondents. This is very interesting as it suggests that either the experience of the H2 buses in Luxembourg has had the effect of reducing support, which would require further research to explore the reasons why. Alternatively, these results might indicate that onboard respondents in Luxembourg have self-selected themselves to the survey because they were not satisfied with the buses.

Table 7 presents mean ratings of various features of the H2 buses: namely, respondents were asked to rate several features of the H2 buses, compared to conventional buses, using a scale from 1 (much worse) to 5 (much better). As expected given the distribution of attitudes shown in Figure 8, Luxembourg onboard respondents rated the buses less positively compared to the Berlin onboard sample. This may simply reflect the fact that Luxembourg respondents are very satisfied with their existing buses, as evidenced by results in Table 4, where Luxembourg bus users gave their existing buses the highest rating, compared to the partner cities.

Table 7: Mean rating of H2 bus features

Characteristics	Berlin (n=70)	Luxembourg (n=49)
Bus appearance	4.10	3.71
Comfort	4.05	3.73
Vibrations	4.03	3.92
Fumes	4.20	3.67
Noise	3.83	3.73
Overall travel experience	4.04	3.75

3.11 Onboard experience of H2 bus users

In the London ex post survey, respondents (n=11) who claimed to have travelled on one of the H2 buses being trialled were asked to complete an additional set of questions similar to those completed by onboard respondents in Berlin and Luxembourg. Given the small sample size, these interviews can be considered as a pilot survey for a future survey on the London H2 bus users.

Frequency of usage of these H2 buses varied: four respondents had used them at least ten times, whilst six of the HFCB users had travelled on them between 2 and 5 times. No problems were encountered on any of the trips made. Respondents were then asked to rate several features of the H2 buses, compared to conventional buses, using a scale from 1 (much worse) to 5 (much better). There was almost a unanimous

agreement that the H2 buses were a little (7 respondents) or much better (2 respondents) than conventional buses, and only one respondent said that they were equivalent.

The features that received the best ratings were *"fumes"* (mean rating of 4.45) and *"vibrations"* (4.36), which were considered a little or much better than conventional buses by the majority of respondents. These results are very similar to those presented for onboard respondents in Berlin and Luxembourg. There was a narrower consensus about the *"aesthetics"* (3.55) of the new buses with 6 respondents saying that it was a little or much better than conventional buses, against the 2 respondents who said it was a little worse. The only surprise occurred when users were inquired about the *Noise* (3.09) of the H2 buses, since only 2 respondents considered it a little better than conventional buses, while one considered it a little worse, and the majority considered it equivalent.

Finally, when asked about their opinions about the information provided on board the H2 buses, most respondents perceived the quality of the information available as average, overall, and one respondent considered it bad. This indicates a need for a more attractive information setup in the buses. However, only two users were interested in receiving more information on the H2 buses.

4. PREFERENCES OF BUS USERS

This section presents summary WTP statistics from the ex post surveys for each city, and compares values across surveys sub samples and cities. This is followed by Section 4.2, which compares ex ante survey WTP statistics with ex post statistics.

4.1 Ex post WTP statistics

All bus-users in the ex post survey (n=962) were asked if they would be willing to pay extra per single bus fare to support the large-scale introduction of H2 buses in their respective cities. Specifically, respondents were asked how much they would be willing to pay on top of a standard single 2.00€ ticket in Berlin, £1.00 ticket in

London, 1.20€ ticket in Luxembourg and AU$2.00 in Perth. Those who were willing to pay were asked to indicate how much using a payment ladder (see Figure 1). Respondents were also asked if they would be willing to pay extra taxes (WTP_X) to support the large-scale introduction of hydrogen buses, and WTP was also elicited using a payment ladder. Table 8 presents summary statistics for the estimated values for the WTP_S payment vehicle for the ex post survey, and Table 9 shows summary statistics for the WTP_X payment vehicle. These shall be discussed in turn.

Table 8: WTP extra bus fare of paying bus users (*ex post*)

	Berlin	London	Luxembourg	Perth	ALL
Randomly selected respondents					
Sample WTP_S >0	29	148	123	136	436
Sample WTP_S =0 (valid)	7	5	8	6	27
Sample WTP_S =0 (protests)	11	30	26	7	73
% protests	23	16.4	14.6	4.70	13.6
WTP_S Statistics					
Median WTP_S excl. protests (national currency)	€0.20	£0.20	€0.20	AU$0.20	-
Mean WTP_S excl. protests and outliers (national currency)	€0.33	£0.29 (a)	€0.42	AU$0.42	-
Mean WTP_S (converted to €)	0.33	0.42	0.42	0.25	0.36
Repeat respondents					
Sample WTP_S >0	109	56	75	-	240
Sample WTP_S =0 (valid)	8	1	17	-	26
Sample WTP_S =0 (protests)	29	9	5	-	43
% protests	19.9	11.7	5.2	-	13.9
WTP_S Statistics					
Median WTP_S excl. protests (national currency)	€0.20	£0.20	€0.30	-	-
Mean WTP_S excl. protests and outliers (national currency)	€0.37	£0.27	€0.39	-	-
Mean WTP_S (converted to €)	0.37	0.39	0.39	-	0.38
On-board H2 bus respondents					
Sample WTP_S >0	45	-	36	-	81
Sample WTP_S =0 (valid)	13	-	11	-	24
Sample WTP_S =0 (protests)	12	-	0	-	12
% protests	16	-	0 (c)	-	10.2
WTP_S Statistics					
Median WTP_S excl. protests (€)	0.20	-	0.20	-	-
Mean WTP_S excl. protests and outliers (€)	0.25 (b)	-	0.48 (d)	-	0.37

(a) London: 1 outlier of £5 removed
(b) Berlin: four outliers of 10€ (x2), 20€ and 50€ removed.
(c) Zero WTP responses in the Luxembourg onboard survey were not followed up hence they could not be classed as valid or protest. In this analysis they have been classed as valid; if they were classed as protests, mean WTP (excluding one outlier of 15€) would be 0.63€.
(d) Luxembourg: one outlier of 15€ removed.

Table 9: Willingness to pay extra taxes of bus user respondents (*ex post*)

	Berlin	London	Luxembourg	Perth	ALL
First-time respondents					
Sample $WTP_X > 0$	16	102	75	76	310
Sample $WTP_X = 0$ (valid)	3	18	6	7	38
Sample $WTP_X = 0$ (protests)	28	63	76	37	225
% protests	59.6	34.4	48.4	19.9	39.3
WTP_X Statistics					
Median WTP_X excl. protests (national currency)	10.00€	£20.00	30.00€	AU$20.00	-
Mean WTP_X excl. protests and outliers (national currency)	18.01€	£30.61 (a)	36.84€ (b)	AU$28.94	-
Mean WTP_X (converted to €)	18.01	44.36	36.84	17.33	29.14
Repeat respondents					
Sample $WTP_X > 0$	80	41	64	-	185
Sample $WTP_X = 0$ (valid)	7	4	5	-	16
Sample $WTP_X = 0$ (protests)	59	21	28	-	108
% protests	40.4	31.8	28.9	-	35.0
WTP_X Statistics					
Median WTP_X excl. protests (national currency)	10.00€	£22.50	10.00€	-	-
Mean WTP_X excl. protests and outliers (national currency)	22.80€	£44.35 (c)	19.74€	-	-
Mean WTP_X (converted to €)	22.80	64.28	19.74	-	-
On-board H2 bus respondents					
Sample $WTP_X > 0$	40	-	26	-	66
Sample $WTP_X = 0$ (valid)	25	-	21	-	46
Sample $WTP_X = 0$ (protests)	5	-	0	-	5
% protests	7	-	0 (d)	-	4.3
WTP_X Statistics					
Median WTP_X excl. protests (national currency)	1.50	-	1.50	-	-
Mean WTP_X excl. protests and outliers (€)	9.18	-	11.92	-	-

(a) London: one outlier of £600 removed. (b) Luxembourg: one outlier of 300€ removed.
(c) London: two outliers of £500 and £400 removed.
(d) Zero WTP_X responses in the Luxembourg onboard survey were not followed up hence they could not be classed as valid or protest. In this analysis they have been classed as valid; if they were classed as protests, mean WTP_X would be double the value in the table, at 21.55€.

As results in Table 8 show, the proportion of protest zero WTP_S responses is higher amongst Berlin respondents compared to the other cities. Protests are zero WTP values that do not reflect the true value that the respondent places on the good in question, but rather reflect a 'protest' against the payment vehicle being used to elicit values (Bateman et al, 2002). Protests, if identified, are usually dropped from the analysis. This high rate of protest WTP_S values amongst Berlin respondents is likely to be associated with attitudes to existing bus fares. As we saw in Table 4, mean attitude towards bus fares in Berlin was much lower than mean attitude in the other three cities - probably due to the price of a single bus fare, which is about 1€ higher in Berlin. These results are very similar to those from the ex ante survey, where Berlin bus users protested against paying extra bus fares much more than bus users from the other cities (see Deliverable 6).

However, results in Table 9 show that Berlin respondents also protest most often against paying extra tax to support the introduction of H2 buses in their city. This is likely to be because tax rates are perceived to be very high in Berlin, as can be seen from political discussions in Germany. Overall rates of protest against paying extra taxes are higher in all the cities, compared to protest rates against paying extra bus fares; high protest rates frequently occur when using tax-based payment vehicles, as respondents are often averse to paying more tax (Garrod and Willis, 1999).

Inspection of mean single bus fare (WTP_S) values in Table 8 indicates that random and repeat bus user respondents have similar mean WTP values in all cities; median values appear to be quite stable across *all* sub samples, indicating that the preferences of the majority are consistent. Onboard respondents appear to have provided more varied mean economic values: in Berlin onboard WTP_S was €0.25 per single bus fare, and in Luxembourg, onboard respondents were willing to pay €0.42. However, in both cases the sample sizes are small and mean values should be interpreted with caution.

Mean and median WTP extra tax (WTP_x) values, presented in Table 9, are less consistent across sub samples: we find that repeat respondents in Berlin and London are willing to pay significantly more taxes to support the introduction of H2 buses in their cities. In Luxembourg the opposite is true. Interestingly, onboard respondents are

willing to pay significantly lower taxes than either of the other sub samples in Berlin and Luxembourg (although in the case of Luxembourg, this value is much higher if the zero WTP values are classed as protests). The median value for onboard respondents is particularly low at €1.50 in both cities, compared to between €10 and €30 for the other sub samples. It is suggested that the lower WTP amongst on-board respondents may reflect the fact that they have just paid to use the bus, and are in effect 'protesting' against being asked for more money. However, if this were the case, then it would be expected that WTP per single bus fare would also be lower for on-board respondents. However, as noted, one cannot speculate too much about the on-board survey results due to the small sample sizes.

4.2 Comparing ex post WTP across cities

Before comparing WTP values *across cities*, they need to be converted to a common currency. In this case, all values have been converted to Euros (€), as valued in April 2005. Exchange rates are shown in the first column of Table 10.

However, it is also necessary to adjust values according to the cost of living in each city, as 1€ may have very different purchasing power in each city. For example, a mean WTP of 1€ may represent a negligible amount in one city whereas it might make up a significant proportion of an individual's disposable income in another city. Mercer Consultants provide 'cost of living' indices for cities worldwide, which reflect the different costs in each city of a standard bundle of goods. Using these indices, mean WTP values can be adjusted to account for the cost of living (Ready et al, 2004). Cost of living indices are presented with reference to US dollars, so the value of Euros in Berlin was used as the baseline[7]. As figures in the second column of Table 10 show, the cost of living is highest in London and lowest in Perth.

[7] All cost of living indices were divided by the cost of living index for Berlin, which would make Berlin the baseline (cost of living=1).

Table 10: Financial and Cost of Living Adjusted Exchange Rates

	Financial exchange rate (April 2005)	Cost of living - adjusted by city (Mercer Consultants)
Berlin, Germany (€)	1.00	1.00
London, UK (£)	0.69	1.38
Luxemburg (€)	1.00	0.98
Perth, Australia (AU$)	1.67	0.83

Mean WTP_S was therefore converted to a common currency (€) and adjusted to account for the cost of living in each of the cities. These values are presented for each sub sample in Table 11.

Table 11: Adjusted WTP values

	Berlin	London	Luxembourg	Perth	ALL
Randomly selected respondents					
Mean WTP_S (converted to €)	0.33	0.42	0.42	0.25	0.36
Adjusted Mean WTP_S (€)	0.33	0.30	0.43	0.30	-
Mean WTP_X (converted to €)	18.01	44.36	36.84	17.33	29.14
Adjusted Mean WTP_X (€)	18.01	32.14	37.59	20.88	-
Repeat respondents					
Mean WTP_S (converted to €)	0.37	0.39	0.39	-	0.38
Adjusted Mean WTP_S (€)	0.37	0.28	0.40	-	-
Mean WTP_X (converted to €)	22.80	64.28	19.74	-	35.61
Adjusted Mean WTP_X (€)	22.80	46.58	20.14	-	-
On-board respondents					
Mean WTP_S (€)	0.25	-	0.48	-	0.37
Adjusted Mean WTP_S (€)	0.25	-	0.49	-	-
Mean WTP_X (€)	9.18	-	11.92	-	10.55
Adjusted Mean WTP_X (€)	9.18	-	12.16	-	-

Results in Table 11 indicate that mean adjusted WTP per single bus fare (WTP_S) is very similar for randomly selected bus users in Berlin, London and Perth (€0.33, €0.30 and €0.30 respectively), suggesting that the perceived benefits of H2 buses to bus users in these cities are quite similar. Randomly selected respondents from

Luxembourg however were willing to pay between 7 and 10 cents more per single bus fare than respondents from other cities, and the difference is statistically significant at the 1% level. Repeat respondents from Luxembourg also have the highest adjusted WTP_S values, whilst repeat respondents from London have the lowest adjusted value. If we consider the percentage increase on a single bus fare that respondents are willing to pay, Luxembourg respondents from every sub sample are willing to pay the highest percentage increase, ranging between 32% and 48%, on their 1.20€ ticket. Berlin respondents are willing to pay the lowest percentage increase on a standard 2.00€ ticket (between 14% and 17%). These results appear to reflect the price of a single bus fare, which are highest in Berlin.

As with the WTP_S mechanism, mean WTP_X values were converted to Euros and adjusted to the cost of living. Mean WTP_X (in €) amongst randomly selected respondents is highest in the London sample (€44.36), and lowest in the Berlin sample (€18.01), although when adjusted to account for the cost of living, mean WTP_X is highest amongst Luxembourg bus users. Repeat respondents from the London bus user sample however are willing to pay much higher taxes than either Berlin and Luxembourg respondents; this is quite the opposite of results for WTP single bus fares, where London repeat respondents were willing to pay the least (in terms of adjusted values).

As with the payment WTP_S vehicle, onboard respondents from Berlin are willing to pay much less in terms of extra taxes than the other sub samples from the same city. This is also the case however for the Luxembourg onboard respondents, which stands in contrast to on-board respondents WTP per single bus fare (on-board respondents in Luxembourg were willing to pay significantly higher amounts per bus fare than respondents from the other Luxembourg sub samples). This suggests, that in the case of Luxembourg onboard respondents, their stated WTP for H2 buses is very much dependent on the payment vehicle used.

Overall, results indicate that there is a positive WTP for H2 buses. This is an encouraging result for hydrogen developers. It indicates that the public positively values the environmental benefits of these buses, and are willing to pay to support their introduction.

The next key issue is to compare WTP for the large-scale introduction of H2 buses in each city from the ex ante studies with WTP values from the ex post studies. The purpose of examining this question is to assess whether there has been any change in public preferences, and more specifically: *has there been any change in public WTP for hydrogen buses since the beginning of the bus trials?* This is the question that the next section, and Section 4.3, will address.

4.3 Comparing ex ante and ex post survey WTP statistics

Table 12 presents *mean unadjusted WTP values (in each city's national currency)* from the ex ante and ex post surveys. Full ex ante survey results can be found in the ex ante comparative report (Deliverable 6, Work Package 6).

Table 12: Comparing ex ante and ex post WTP of bus users in each city

	Ex ante WTP	**Ex post WTP**		
		random	**repeat**	**onboard**
$\underline{WTP_S}$				
Berlin (€)	0.30	0.33	0.37 *	0.25
London (£)	0.27	0.29	0.27	-
Luxembourg (€)	0.42	0.42	0.39	0.48
Perth (AU$)	0.48	0.42	-	-
$\underline{WTP_X}$				
Berlin (€)	29.07	18.01 **	22.80 *	9.18 ***
London (£)	24.24	30.61	44.35 **	-
Luxembourg (€)	20.62	36.84 ***	19.74	11.92 ***
Perth (AU$)	26.71	28.94	-	-

* Significantly different to ex ante value at 10% level; ** at 5% level; *** at 1% level

As can be observed, mean WTP per single bus fare has remained stable over time, despite the different socio-economic characteristics of the ex ante and ex post survey samples. Only repeat respondents in Berlin have a higher WTP_S, but this is only significant at the 10% level. Ex ante and ex post WTP extra taxes, however, is significantly different for Berlin and Luxembourg samples. Thus, random ex post bus

users in Berlin are willing to pay less taxes than ex ante respondents, whereas in Luxembourg, random ex post respondents are willing to pay more than ex ante respondents. Only onboard respondents in both cities are willing to pay significantly lower taxes to support the introduction of H2 buses in their cities. WTP_X in London and Perth has remained largely stable, although repeat respondents to the ex post survey in London are willing to pay significantly higher taxes.

In order to assess whether these changes are not merely a consequence of the different socio-economic and attitudinal characteristics of the ex ante and ex post samples, it is necessary to carry out regression analyses on pooled ex ante and ex post data, in which these various variables are controlled for, and hence, real changes in WTP can be assessed. These regression analyses are to be found in the next section.

5. ECONOMETRIC ANALYSES

This section presents the regression analyses carried out on the pooled ex ante and ex post data. The purpose of carrying out such analyses is twofold: firstly, they allow us to identify which variables influence knowledge, acceptability and WTP for H2 buses and storage in the various cities.

Secondly, these analyses allow us to identify whether there have been statistically significant changes in knowledge, acceptability and WTP for H2 technologies; specifically, the significance and direction of influence of the variable 'EXPOST' (indicating whether the data is ex ante or ex post) will allow us to identify such changes. Table 13 presents the variables included in these regressions.

Table 13: Variables used in Regressions

Variable	Description
Dependent Variables	
H2KNOW	Dummy for knowledge about H2 vehicles: 1=yes/ 0=no
SUPPH2BUS	Dummy for respondents who unconditionally support the large-scale introduction of H2 buses in their cities: 1=yes/ 0=no
WTP_S	Willingness to pay extra per single bus fare to support introduction of H2 buses in city
WTP_X	willingness to pay extra taxes to support introduction of H2 buses in city
Independent Variables	
YADJ	Income taken as mid interval of income levels (and divided by 10000)
AGE	Respondent's age
MALE	Dummy indicating gender: 1=male/ 0=female
UNIVEDUC	Dummy for whether respondent has university education: 1=yes/ 0=no
TRIPNOS	Dummy indicating frequent bus use: 0=under 5 times a week/ 1=over 5 times a week
RATEFUME	Attitude towards level of fumes produced by existing buses (from 1-very poor to 5-very good)
RATENOISE	Attitude towards level of noise produced by existing buses (from 1-very poor to 5-very good)
H2KNOW	Dummy for knowledge about H2 vehicles: 1=yes/ 0=no
ENVATT	Attitude to statement: "*Solving environmental problems should be one of the top 3 priorities for public spending in [city]"* (from 1-strongly disagree to 5-strongly agree)
TECHNATT	Attitude to statement: "*Science and technology are the key to solving environmental problems in [city]"* (from 1-strongly disagree to 5-strongly agree)
ENVKNOW1	Agreement with statement: "*The main cause of climate change is the hole in the ozone layer"* (from 1-strongly disagree to 5-strongly agree)
ENVKNOW2	Agreement with statement: "*Car use is the main cause of air pollution in cities"* (from 1-strongly disagree to 5-strongly agree)
USEDH2BUS	Dummy indicating whether respondent (ex post) has used a H2 bus: 1=yes/ 0=no
REPEAT	Dummy indicating whether ex post respondent also completed ex ante survey: 1=yes/ 0=no
ONBOARD	Dummy indicating whether respondent (ex post) completed the onboard H2 survey bus: 1=yes/ 0=no
EXPOST	Dummy indicating whether respondent completed ex post survey: 1=yes/ 0=no

5.1 Logit regressions on knowledge about hydrogen

A logit regression was used to identify which variables influence respondents' likelihood of having prior knowledge about hydrogen-powered vehicles (see Section 3.6 for descriptive statistics), and in particular, whether there has been a statistically significant increase in knowledge between the ex ante and ex post survey time period. Table 14 presents the regression results for each city. Inspection of results indicates that there is only one variable that influences the likelihood of knowing about H2 vehicles in *all the city samples,* and that variable is gender. Thus, men are significantly more likely than women to have prior knowledge about H2 vehicles in all the cities. This is quite reasonable given that men tend to have greater interest in cars and new technologies.

Otherwise, results suggest that, for the most part, the determinants of knowledge are quite different for each sample, although some variables certainly appear to influence several models. For example, university education has a significantly positive influence on knowledge likelihood in London, Luxembourg and Perth, whilst knowing about the causes of climate change (indicated by disagreement with the statement: "*The main cause of climate change is the hole in the ozone layer"*) is also closely related to knowledge about H2 in these cities. These relationships are expected, as education increases the accessibility of information to individuals; this is because education increases the ability to search for information, and understand it (Bundorf et al, 2004). Interestingly, age has a varied relationship with knowledge likelihood in different cities: in London and Perth, older people are more likely to know about H2 vehicles, whilst in Berlin, younger people are more likely to know. This may be related to the sources of information about hydrogen, and the age groups that these sources appeal to.

Table 14: Pooled model results – logit regression on H2KNOW of *bus users* (first-time respondents *not* on-board a H2 bus)

	Berlin		London		Luxembourg		Perth	
	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio
YADJ	-0.061	-1.02	0.068 *	1.74	0.149 ***	2.57	0.021	0.40
MALE	1.532 ***	5.20	0.898 ***	4.13	1.137 ***	4.42	1.442 ***	4.69
AGE	-0.016 **	-2.13	0.018 **	2.27	0.000	0.01	0.020 **	2.11
UNIVEDUC	0.472	1.45	0.459 **	2.05	0.674 ***	2.58	0.920 ***	2.86
ENVATT1	0.217	1.30	0.044	0.34	-0.174	-1.14	0.373 **	2.07
TECHNATT	0.035	0.23	0.154	1.30	0.050	0.37	0.100	0.57
ENVKNOW1	-0.059	-0.47	-0.316 ***	-2.84	-0.317 **	-2.56	-0.779 ***	-4.71
ENVKNOW2	0.008	0.06	0.158	1.33	0.007	0.06	-0.033	-0.20
EXPOST	0.548	1.20	0.166	0.74	0.504 **	1.98	0.589 **	2.05
Constant	0.549	0.53	-2.041 **	-2.48	0.479	0.50	-1.372	-1.1
Pseudo-R2	0.12		0.10		0.13		0.18	
Chi2 (dof)	(9) 53.85		(9) 60.02		(9) 68.34		(9) 67.37	
No. of observations	385		422		379		269	

* Significant at 10% level, ** at 5% level, *** at 1% level

Finally, and perhaps most importantly, the variable EXPOST is only significant in Luxembourg and Perth, indicating that there has been a significant increase in public awareness about H2 vehicles since the initial ex ante survey, in these two cities only. In both cases, there were concerted information and public outreach campaigns associated with the H2 bus trials. In Perth, the campaign included: brochures about the project on-board buses, and sent to schools and industry partners, cut-out cardboard model buses sent to schools, a dedicated website, a TV programme, articles in the local newspapers, various radio interviews and conferences associated with the launch of the H2 bus trials. In Luxembourg, the local public transport operator[8] made radio commercials and the fuel cell buses participated the Luxembourg Spring Fair. In addition, there were group visits for teachers, students, retirees and other interested parties.

In Berlin and London, there has been no actual increase in knowledge about hydrogen since the original survey. In Berlin, this may simply be a consequence of the flattening of the learning curve in the population. Learning curves are typically depicted as sigmoidal curves, indicating a slow initial uptake of information amongst the population, followed by a steep rate of increase, and then a flattening of the curve. As noted, knowledge levels amongst ex ante Berlin respondents were very high, with almost three quarters (72%) of the ex ante sample having knowledge about H2 vehicles, leaving less scope for increase in awareness. Furthermore, in Berlin the H2 bus trial involved only one bus over a restricted period of about 6 months, hence limiting the impact on awareness amongst the population.

In London on the other hand, only 48% of respondents had heard about H2 vehicles, suggesting a greater potential for increase in knowledge in London than in Berlin. The fact that there has been no significant increase in public awareness about hydrogen in London, 6 months into the trial of three H2 buses in the city, suggests that any information and dissemination activities relating to this trial have been largely ineffective. However, it is important to account for the different size of each of the cities

[8] Autobus de la Ville de Luxembourg (AVL)

in this study, as this will influence the relative public exposure of H2 bus trials: Berlin has a population of 3.5m, Perth has a population of 1.5m, Luxembourg has a population of 450,000 and London has a population of almost 8 million individuals. These figures may help explain why London ex post respondents are much less aware of the bus trials, whilst Luxembourg and Perth respondents are much more aware.

5.2 Logit regressions on support for the introduction of hydrogen buses

As with the previous analysis, a logit regression was used to identify which variables influence respondents' likelihood of unconditionally supporting the large-scale introduction of H2 buses in their cities (see Section 3.8 for descriptive statistics), and in particular, whether there has been a statistically significant increase in unconditional support between the ex ante and ex post survey time period. Results are presented in Table 15.

Results in Table 15 confirm that unconditional support for the large-scale introduction of H2 buses has increased significantly in every city (indicated by positive coefficient on EXPOST), independent of the other variables included in the regressions.

It appears that therefore, ex post bus users were more likely to unconditionally support H2 buses as a result of some factor that has changed over the 1-year period between the ex ante survey, and the ex post survey, which was not measured in the surveys. For example, increased awareness about and/or support for other new alternative energy technologies might positively influence unconditional support towards the introduction of H2 buses. In London, for example, there have been a number of television programmes and newspaper articles over the past year about climate change and transport-related impacts on climate change; it is possible that this information has influenced attitudes towards new environmental technologies, such that respondents are more likely to express unconditional support despite no prior knowledge about H2 technology *per se*. This is an area that would benefit from future research.

Table 15: Pooled model results: logit regression on SUPPH2BUS for *bus users* (first time, repeat and onboard respondents)

	Berlin		London		Luxembourg		Perth	
	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio
YADJ	-0.092 **	-2.16	-0.040	-1.14	0.026	0.55	-0.006	-0.13
MALE	0.066	0.33	0.034	0.17	0.073	0.32	0.111	0.41
AGE	-0.012 **	-2.05	-0.012	-1.59	-0.002	-0.40	0.001	0.15
UNIVEDUC	-0.037	-0.17	-0.122	-0.59	0.026	0.11	-0.050	-0.17
ENVATT1	0.416 ***	3.34	0.379 ***	3.21	-0.042	-0.32	0.114	0.71
TECHNATT	-0.112	-0.98	0.112	1.03	-0.156	-1.26	0.118	0.76
ENVKNOW1	-0.113	-1.25	0.008	0.08	0.033	0.29	0.268 *	1.82
ENVKNOW2	0.189 *	1.88	0.036	0.33	0.072	0.67	0.112	0.77
H2KNOW	0.631 ***	2.84	0.089	0.42	1.256 ***	5.38	0.893 ***	3.01
USEDH2BUS	1.370	1.28	-0.157	-0.21	0.174	0.33	0.304	0.46
ONBOARD	-0.472	-0.92	-	-	-1.356 ***	-2.87	-	-
REPEAT	-0.366	-0.84	-0.240	-0.71	-0.062	-0.16	-	-
EXPOST	1.010 **	2.48	1.154 ***	5.10	1.015 ***	3.73	0.598 **	2.25
Constant	-0.979	-1.31	-1.583 **	-2.07	-0.004	0.00	-3.309 ***	-2.80
Pseudo-R2	0.08		0.07		0.12		0.06	
Chi2 (dof)	(13) 64.46		(12) 45.28		(13) 78.26		(11) 25.00	
No. of observations	575		490		521		281	

* Significant at 10% level, ** at 5% level, *** at 1% level

In the Berlin and Luxembourg surveys a number of respondents (n=70 and n=47 respectively) answered the *ex post* questionnaire on-board a H2 FC bus (denoted by the dummy variable 'ONBOARD'). These respondents were not asked to indicate their knowledge about the development of H2 FC vehicles hence there is no data for H2KNOW for these respondents. In order to include both variables (H2KNOW and ONBOARD) in the Berlin and Luxembourg regressions, it was assumed that on-board respondents were aware of the development of H2 FC vehicles, and hence they were given a value of '1' with respect to the H2KNOW dummy variable.

Other influences on unconditional support include prior knowledge about H2 vehicles, which is a very strong driver for support in Berlin, Luxembourg and Perth. This positive relationship between knowledge and support is likely to be a direct consequence of the largely positive nature of the available information about hydrogen in the public domain (O'Garra, Mourato and Pearson 2005). Agreement with the statement *"Solving environmental problems should be one of the top 3 priorities"* is also a significant driver for support, in Berlin and London only.

Finally, it is interesting to note that respondents who have used a H2 bus are not more likely to unconditionally support their large-scale introduction. This raises a number of key questions about the effectiveness of these trials in 'convincing' members of the public about their value. If riding on one of these buses has no significant influence on the likelihood of support, then one needs to question whether these buses are providing the same level of performance, comfort, reliability of conventional buses. Additionally, one needs to question whether the information provided on board these buses was adequate, clear and properly placed for individuals to become informed. As results in Sections 3.10 and 3.11 show, information provided onboard H2 buses in was rated average overall, suggesting a need for a rethink as to the presentation of this information.

Overall, despite a lack of significant increase in knowledge about hydrogen transport technologies in two of the study cities (Berlin and London) over a 1-year period, there has been a significant increase in unconditional support for the large-scale introduction of H2 buses in every one of the cities in this study. This is, in a preliminary sense, a positive result for hydrogen developers.

However, these results are indicative of changes in *attitudes*, and attitudes tend to reflect ideals rather than actual intentions with respect to the good in question (Kurani et al, 1996). Attitudes merely guide intentions and, crucially, imply no trade-offs between one's limited budget and securing cleaner transport alternatives. As discussed in the 'Review of Existing Studies' (Work Package 3), studies based solely on attitude

questions, tend to reveal very positive attitudes towards cleaner transport amongst respondents, in contrast with experimental and preference surveys which show lower acceptance levels overall for cleaner transport (Gould and Golob, 1998). As proposed in Fishbein's Theory of Reasoned Action (1977), intention (i.e. as measured by willingness to pay) is a better indicator of behaviour than attitudes.

Thus, Section 5.3 will address the question of whether the increase in unconditional support for the large-scale introduction of H2 buses is matched by a similar increase in WTP to support such an introduction.

5.3 Interval regressions on WTP for hydrogen buses

Variables influencing respondents' WTP to support the large-scale introduction of H2 buses in their respective cities for both payment mechanisms (single bus fare, and annual tax payments) were determined using interval regressions. Payment ladder values may be treated as interval data because the respondent's maximum WTP may lie anywhere between the value ticked on the payment ladder and the next value up (Cameron and Huppert, 1989). Table 13 at the start of Section 4 presents the variables used in the regressions. The following section presents pooled model results.

Regression Results

A normal distribution of WTP was used for the models, as overall this functional form performed better than lognormal distributions. Tables 16 and 17 present the results of the regressions on pooled WTP_S and WTP_X data for ex ante bus users, and randomly selected and repeat ex post survey bus users. Regressions incorporating onboard H2 bus respondents are carried out separately for Berlin and Luxembourg, due to the different nature of some of the variables used in these regressions. These regressions are found in Table 18.

Note that there was a high proportion of missing income values in both the Luxemburg and Berlin samples: in the Luxemburg ex ante sample 147 respondents (49% of sample) did not state their income, and 106 did not state their income in the ex post survey (35.2% sample). In the Berlin surveys, 124 ex ante respondents (36%) and 164 (54.7%) of ex post respondents did not state their income. Regressions involving the income variable would therefore miss out almost half the data in both cases; hence missing values were dealt with by imputing average income values for the sample; as shown in Table 1, average income is 39,124€ and 49,569€ in the Luxemburg ex ante and ex post samples respectively; average income was 31,598€ and 34,349€ in Berlin ex ante and ex post samples. Missing income values accounted for less than 10% of the London and Perth samples, and so no missing values were imputed.

Table 16: Pooled model results: interval regression on WTP_S for first-time and repeat respondents only

	Berlin (WTP_S) (a)		**London (WTP_S)** (b)		**Luxembourg (WTP_S)** (c)		**Perth (WTP_S)** (d)	
	coeff	t-ratio	coeff	t-ratio	coeff	t-ratio	coeff	t-ratio
YADJ	0.014 **	2.07	0.009 **	2.20	0.012	0.97	0.028 **	2.31
MALE	-0.026	-0.82	-0.007	-0.24	-0.025	-0.48	-0.016	-0.34
AGE	-0.001	-0.65	-0.002 ***	-2.69	-0.005 ***	-2.91	-0.004 **	-1.96
UNIVEDUC	0.027	0.73	-0.027	-1.09	-0.009	-0.17	0.249 ***	3.04
ENVATT1	0.032 *	1.66	0.055 ***	4.17	0.037	1.09	0.142 ***	3.86
H2KNOW	0.046	1.30	0.024	0.82	-0.024	-0.45	0.045	0.58
USEDH2BUS	0.131	1.50	-0.021	-0.27	0.028	0.31	-0.198	-1.34
RATEFUME	-0.037 **	-2.13	0.009	0.69	0.008	0.20	-	-
TRIPNOS	-0.048	-1.51	-0.034	-1.44	0.015	0.27	-	-
REPEAT	-0.011	-0.14	0.001	-0.03	-0.020	-0.27	-	-
EXPOST	0.052	0.70	-0.007	-0.23	0.045	0.74	0.002	0.02
Constant	0.288 **	2.52	0.169 **	2.44	0.429 **	2.55	-0.678	-0.27
Sigma	0.289		0.239		0.506		0.508	
Log pseudo-likelihood	-836.44		-888.18		-1122.28		-544.04	
Prob>chi2	0.007		0.000		0.176		0.000	
No. of observations	402		425		420		240	

* Significant at 10% level, ** at 5% level, *** at 1% level

(a) 8 outliers between 3€ and 50€ were removed from the Berlin regression. These accounted for 1.7% of the sample of valid WTP_S estimates.
(b) One outlier of £5 was removed from the London regression.
(c) One outlier of 15€ was removed from the Luxembourg regression.
(d) The ex post survey in Perth did not elicit RATEFUME or TRIPNOS data; in addition the ex post sample for Perth only consisted of first-time respondents. No outliers were removed from the Perth regression.

Table 17: Pooled model results: interval regression on WTP_X for first-time and repeat *bus user* respondents only

	Berlin (WTP_X) (a)		**London (WTP_X)** (b)		**Luxembourg (WTP_X)**		**Perth (WTP_X)**	
	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio
YADJ	1.59 ***	2.79	3.57 ***	2.68	1.80	1.45	2.03 ***	3.46
MALE	2.39	0.74	8.65	1.59	-0.55	-0.13	-6.75 *	-1.74
AGE	0.14	1.36	0.19	1.08	-0.03	-0.26	0.09	0.68
UNIVEDUC	-3.36	-0.99	2.02	0.39	8.43 *	1.94	10.18 **	2.39
ENVATT1	3.33	1.52	7.54 **	2.22	-0.16	-0.07	4.82 **	2.18
H2KNOW	23.60 *	1.72	2.19	0.36	4.21	0.99	6.40	1.59
USEDH2BUS	5.24	1.50	-14.99	-1.25	6.65	1.00	1.09	0.08
RATEFUME	-2.59	-1.32	3.89	1.42	-3.51	-1.34	-	-
TRIPNOS	1.87	0.55	11.29 *	1.79	-6.55	-1.58	-	-
REPEAT	1.36	0.20	21.17 *	1.73	-18.51 ***	-3.32	-	-
EXPOST	-10.89 *	-1.69	2.95	0.55	8.88 *	1.69	4.10	1.11
Constant	7.36	0.55	-44.44 *	-1.85	30.04 *	1.87	-14.43	-1.20
Sigma	24.48		44.30		31.81		23.39	
Log pseudo-likelihood	-881.60		-1340.86		-959.90		-577.266	
Prob>chi2	0.000		0.037		0.015		0.000	
No. of observations	264		304		265		169	

* Significant at 10% level, ** at 5% level, *** at 1% level

(a) Three outliers of 200€ omitted from Berlin regression.
(b) Four outliers of £400, £500 (2) and £1000 omitted from London regression

Results in Table 16 indicate that there is no one variable that influences WTP per single bus fare in every city sample, highlighting the different drivers of WTP across geographical areas. Thus, respondents with university education in Perth are willing to pay AU$0.25 more than those without university education; however this determinant has no effect on WTP_S in the other cities. Similarly, attitudes towards the fumes produced by existing buses are a significant driver for WTP_S in Berlin only, such that the more positively the respondent values this attribute of existing buses, the more they are willing to pay. However, common determinants across cities do tend to be similar in terms of the direction of their influence. For example, income has a significantly positive influence in Berlin, London and Luxembourg, as expected, but it has no influence in Luxembourg. This may be simply due to the fact that the WTP_S payment vehicle elicits very small bids, which are maybe not influenced by income levels in these cities. However, it is also likely to be a result of the extent of missing income data for Luxemburg (although Berlin also had a high proportion of missing values) – the imputation of average income values for these missing values means that income influences cannot be properly explored in the regressions.

Notably, results indicate that WTP_S is *not* significantly influenced by when the respondent was interviewed, in any of the cities. Thus, although results in Section 3.8 indicate that there has been a significant increase in unconditional support for the large-scale introduction of H2 buses in the different cities, this has not been matched by a similar increase in WTP per single bus fare.

In Table 17, results indicate that - as with the WTP_S payment vehicle - determinants of WTP extra tax (WTP_X) are quite different for each city sample, and there is no one variable that is a driver for WTP_X in every city. For example, agreement with the statement *"Solving environmental problems should be one of the top 3 priorities…"* has a significantly positive influence on WTP_X in London and Perth, but not in Berlin and Luxembourg. More crucially, income has the expected positive influence in Berlin, London and Perth; however it does not appear to influence WTP_X in Luxembourg (it did

not influence WTP_S either). This raises the question about the theoretical validity of the Luxembourg data sets.

The variable EXPOST has no influence on WTP_X in London and Perth, suggesting that WTP_X in these cities has not changed significantly since the ex ante survey. However, this variable is significant in Berlin and Luxembourg (albeit only at the 10% level), indicating that there has been a change in WTP since the introduction of the H2 bus trials. The direction of this influence however is different in each city: ex post WTP_X is lower in Berlin, and higher in Luxembourg. However, this change in WTP_X must be interpreted with caution, as EXPOST is only significant at the 10% level.

If results in Table 16 are compared to those in Table 17, it becomes clear that, not only are the determinants of WTP different across city samples, but they are quite different for each payment vehicle. For example, age is a significant influence on WTP_S in the London, Luxemburg and Perth samples, but it is not a significant influence on WTP_X in any of the samples. These findings show that the nature of the payment vehicle used to elicit the economic values appears to affect the WTP results significantly. This is not unexpected since values are conditional on the scenario respondents are presented with, and different payment mechanisms may theoretically result in different benefit estimates (i.e. the incentives provided by a tax increase are different from those provided by a bus fare increase). On a policy front, these regressions shed some light on which groups of respondents prefer which payment methods in each city.

The final table in this section (Table 18 below) shows pooled interval regression results for WTP_S and WTP_X of *all* bus user respondents (including on-board H2 bus respondents) in Berlin and Luxembourg.

Table 18: Pooled interval regressions on WTP_S and WTP_S for first-time, repeat *and onboard H2 bus* respondents (Berlin and Luxembourg only)

	WTP_S				WTP_X			
	Berlin (WTP_S) (a)		**Luxembourg (WTP_S)** (b)		**Berlin (WTP_X)** (a)		**Luxembourg (WTP_X)** (b)	
	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio
YADJ	0.015 **	2.20	0.007	0.66	1.342 ***	2.77	1.612	1.48
MALE	-0.010	-0.33	-0.071	-1.38	3.593	1.25	-0.352	-0.09
AGE	-0.001	-0.66	-0.004 ***	-2.74	0.092	1.01	0.004	0.03
UNIVEDUC	0.036	1.03	0.011	0.21	-3.115	-0.99	9.627 **	2.48
ENVATT1	0.037 **	2.06	0.039	1.28	3.124 *	1.66	0.125	0.07
REPEAT	-0.006	-0.08	-0.010	-0.15	2.743	0.43	-17.959 ***	-3.03
ONBOARD	-0.105	-1.25	0.061	0.47	-10.175 *	-1.65	-25.192 ***	-4.36
EXPOST	0.064	0.86	0.046	0.75	-9.024	-1.49	12.762 ***	2.64
Constant	0.159 *	1.66	0.465 ***	2.93	6.589	0.76	14.925	1.34
Sigma	0.293		0.521		24.027		30.839	
Log pseudo-likelihood	-917.53		-1220.83		-1077.79		-1102.03	
Prob>chi2	0.045		0.066		0.000		0.000	
No. of observations	444		456		316		302	

* Significant at 10% level, ** at 5% level, *** at 1% level

(a) 8 outliers between 3€ and 50€ were removed from the Berlin regression. These accounted for 1.7% of the sample of valid WTP_S estimates.
(b) One outlier of 15€ was removed from the Luxembourg regression.

Results in Table 18 indicate that there has been a significant increase in WTP taxes in Luxembourg since the H2 bus trials (indicated by the positive coefficient on EXPOST), whilst Berlin has not experienced a significant change. The increased WTP taxes might possibly be a result of the more concerted information campaign in Luxembourg, which has probably raised awareness and allowed for individuals to assess the trade-offs they are willing to make to secure the introduction of these cleaner buses. However, if this were the case then it would be expected that WTP per single bus fare would also increase. The fact that it hasn't suggests that the payment vehicle may be picking up attitudes associated with it, as opposed to attitudes towards the H2 buses being valued.

6. PREFERENCES OF LONDON AND PERTH POPULATION SAMPLES

As explained earlier, this study was directed primarily at bus users. However, in London and Perth, non-bus users were interviewed as well as bus users, as is was considered of additional interest in these cities to investigate attitudes and preferences of the whole population towards H2 buses. This section therefore presents results for the whole-sample preferences for H2 buses in London and Perth.

6.1 Socio-economic Statistics

Table 19 shows socio-economic characteristics for the whole ex post survey *and* ex ante survey samples (consisting of bus users and non-bus users) for London and Perth. Sample characteristics are compared to population characteristics for these cities.

Table 19: Summary Statistics for London and Perth (bus users and non-bus users)

Variables	London population (n=7.4m)	Ex ante sample (n=414)	Ex post sample (n=300)
LONDON			
Bus users (% respondents)	79	74.4 *	83.0 **
Sex (% men)	48	41.3 ***	45.3
Age (mean)	37	39.0 **	40.2 **
University Degree (% respondents)	24.7	46.1 ***	51.0 ***
Employed (% respondents)	91	80.4	79.7
Household gross annual income (mean £)	38,376	41,964 **	48,745 ***
Car ownership (% households owning car)	61	68.1 *	70.7 **
PERTH	**Perth population (n=1.4m)**	**Ex ante sample (n=300)**	**Ex post sample (n=300)**
Bus users (% respondents)	30	49.0 ***	55.3 ***
Sex (% men)	49	37.7 ***	41.7 **
Age (mean)	44.3	47.1 **	49.9 ***
University Degree (% respondents)	12.1	39.7 ***	35.0 ***
Employed (% respondents)	90	54.1	47.7
Household gross annual income (mean AU$)	46,800	50,239 *	52,335 ***
Car ownership (% households owning car)	?	93.7	92.7

* Significantly different to population statistics at 10% level, ** at 5% level; * at 1% level
Sources: (London) ONS (2004) and Census 2001 (National Statistics, 2002).
(Perth) TNS (2004) and the 2001 Census (ABS, 2001)

As results show, the Perth samples are made up of significantly higher proportions of bus users (49% and 55%) compared to the wider population (30%). In London the differences are less pronounced, as the proportions of bus users in the samples were controlled for during the data collection process. There appears to be a bias in both ex ante and ex post city samples towards older female respondents with university education. Average household income levels of the samples are also higher than average household income

of the population. This indicates possible self-selection of respondents to the questionnaire.

The results presented from hereon will be weighted in order to make the sample representative of the wider population in terms of bus use, gender and education. Weights were not applied with regards to age and income due to the lack of sufficient data on the distribution of these variables for the populations of both cities[9]. Therefore results must be interpreted with this in mind.

6.2 Knowledge and Attitudes

Table 20 presents mean summary statistics for those variables included in the regression analyses in the following sections. These include: H2 knowledge levels, environmental attitudes and knowledge, and whether respondents had used a H2 bus or whether they were repeat respondents.

As results show, there are significantly higher levels of knowledge about H2-powered vehicles in the ex post survey samples of both cities. Mean ratings for ENVATT and ENVBEH suggest that Perth residents are more environmentally minded than Londoners. Additionally, it interesting to note that there are lower levels of agreement with the statement "*Science and technology are the key to solving environmental problems"* amongst ex post respondents in both cities. The effects of these variables on WTP will be investigated in Section 5.4.

[9] Furthermore, in most cases, the sample and population data were gathered differently; hence it was very difficult to make good comparisons. For example, the income intervals used to collect sample income data were different to the intervals used to collect population data in London. They overlapped, but did not coincide at all. It was considered that arbitrary allocation of respondents in overlapping intervals, to particular intervals, would introduce too much error in the estimation process.

Table 20: Mean Summary Statistics for London and Perth

		London		Perth	
Variable	**Description of Variable**	**Ex ante**	**Ex post**	**Ex ante**	**Ex post**
H2KNOW	Dummy for knowledge about H2 vehicles: 1=yes/ 0=no	0.44	0.54	0.45	0.59
ENVATT	Agreement with "*Solving environmental problems should be one of the top 3 priorities for public spending"* (from 1-strongly disagree to 5-strongly agree)	3.87	3.91	4.01	4.01
TECHNATT	Agreement with "*Science and technology are the key to solving environmental problems"* (from 1-strongly disagree to 5-strongly agree)	3.57	3.47	3.69	3.56
ENVKNOW1	Agreement with "*The main cause of global warming is the hole in the ozone layer"* (from 1-strongly disagree to 5-strongly agree)	3.08	3.08	3.15	3.26
ENVKNOW2	Agreement with "*Car use is the main cause of air pollution in cities"* (from 1-strongly disagree to 5-strongly agree)	3.57	3.50	3.47	3.44
USEDH2BUS	Dummy indicating whether a respondent has used a H2 bus: 1=yes/ 0=no	-	0.04	-	0.03
REPEAT	Dummy indicating whether a respondent to the ex post survey had completed the ex ante survey too: 1=yes/ 0=no	-	0.27	-	0.00

6.3 WTP statistics

All respondents in the London ex post survey (n=300) and in the Perth ex post survey (n=300) were asked how much extra annual tax they would be willing to pay to support the large-scale introduction of H2 buses in their respective cities. Table 21 summarises the responses and presents weighted summary WTP statistics.

Table 21: Ex post survey WTP extra annual tax in London and Perth (bus users and non-bus users)

Statistics	London		Perth
	Repeat	**Random**	**Random**
Number of bus users *and non bus-users*	77	223	300
No. respondents WTP_X >0	45	118	145
No. respondents WTP_X =0 (valid)	7	19	13
No. WTP_X =0 (protests)	25	86	62
% WTP_X =0 (protests)	32.5%	38.6%	20.7%
WTP_X Statistics			
Median WTP_X excl. protests (national currency)	£20	£10	AU$20
Mean WTP_X excl. protests and outliers (national currency)	39.85	29.27 (a)	AU$28.94
Mean WTP_X (converted to €)	57.75	42.42	18.51
Adjusted Mean WTP_X (€)	41.85	30.74	22.30

(a) Three outliers of £600, £500 and £400 removed

Inspection of results in Table 21 shows that the proportions of protest responses are high in both city samples, indicating that respondents are 'protesting' about the payment vehicle or the scenario being proposed to them (that of the large-scale introduction of H2 buses in the respective cities). In the London sample, mean WTP values are at least twice the value of the median, indicating that the distribution is skewed to the right – despite removal of three outliers. This is not the case for Perth.

Results for London also show that repeat respondents (those who had also completed the ex ante survey one year earlier) are willing to pay about £10 more than randomly selected, first-time respondents. This might suggest that, given time consider their preferences, repeat respondents put a higher economic value on H2 buses. Alternatively, it may be the case that repeat respondents self-selected themselves to the ex post survey, when initially recruited during the ex ante survey, due to a particular interest or preference for environmental transport in general, or H2 vehicles in particular. However, it may also be that the socio-economic characteristics of repeat respondents differ

significantly from those of random respondents, explaining the different WTP estimates. All these questions will be investigated in the econometric analyses in Section 6.4, where regressions (including the dummy variable 'REPEAT') on support for H2 vehicles and WTP for H2 vehicles will indicate whether repeat respondents are really willing to pay more, or whether this is simply a consequence of their different socio-economic characteristics.

Finally, before comparing WTP values between London and Perth, they must be converted to a common currency. For consistency with the analysis of WTP values of bus users in all cities (Section 4.2), all values have been converted to Euros (€), as valued in April 2005. Exchange rates are shown in the first column of Table 10 in Section 4.2. Values have also been adjusted to the cost of living, using indices provided in the last column of Table 10. These adjusted economic estimates are found in the last two rows of Table 21. Results show that, overall, London respondents appear to value the introduction of H2 buses in the city more than Perth respondents.

Table 22 compares adjusted ex ante and ex post WTP extra annual tax (WTP_X) statistics. Full ex ante statistics can be found in the preliminary analysis report: "Comparative analysis of ex ante data from Berlin, London, Luxembourg and Perth" (Deliverable 6).

Table 22: Comparing ex ante and ex post WTP_X in London and Perth (incl. non-bus users)

	Ex ante WTP_X	**Ex post WTP_X**	
		Repeat	**random**
National currency			
London (£)	23.19	39.85	29.27
Perth (AU$)	21.74	-	28.94
Converted to € & adjusted to cost of living			
London	24.35	41.85	30.74
Perth	15.68	-	22.30

* Significantly different to ex ante value at 10% level; ** at 5% level; *** at 1% level

Results show that mean WTP_X estimates of ex post respondents from both cities are significantly greater than ex ante estimates. Thus, it appears that there has been an increase in WTP since the introduction of the H2 bus trials. However, as noted, the data has not been weighted to account for differences in income levels between the ex ante and ex post samples, hence this increased WTP may simply be a consequence of this lack of weighting.

The econometric analysis in the following section will help elucidate whether there has actually been an increase in WTP_X since the introduction of the H2 buses in both cities.

6.4 Econometric Analyses

This section presents the regression analyses carried out on the pooled ex ante and ex post data for the full London and Perth samples. These analyses allow us to identify which variables influence knowledge, acceptability and WTP for H2 buses and storage in the various cities. They also allow for an examination of statistically significant changes in knowledge, attitudes and WTP since the start of the H2 bus trials. The variables included in these regressions are described in Table 13.

Table 22 presents results from the logit regression on H2KNOW, a binary variable indicating whether a respondent is aware of the existence of H2-powered vehicles (where: 1=yes, 0=no).

Table 22: Pooled model results: logit regression on H2KNOW for London & Perth

	London		Perth	
	coefficient	t-ratio	coefficient	t-ratio
YADJ	0.087 **	2.51	0.068 *	1.93
MALE	0.908 ***	4.73	1.595 ***	7.39
AGE	0.015 **	2.13	0.013 **	2.03
UNIVEDUC	0.513 ***	2.59	0.697 ***	3.05
ENVATT1	0.084	0.75	0.345 ***	2.67
TECHNATT	0.268 **	2.51	-0.016	-0.13
ENVKNOW1	-0.263 ***	-2.68	-0.498 ***	-4.39
ENVKNOW2	0.096	0.91	0.032	0.29
BUSUSER	0.485 **	2.09	0.121	0.58
EXPOST	0.137	0.68	0.618 ***	3.03
Constant	-3.008 **	-3.99	-1.960 **	-2.13
Pseudo-R2	0.11		0.17	
Chi2 (dof)	(10) 82.24		(10) 121.04	
No. of observations	544		520	

* Significant at 10% level, ** at 5% level, *** at 1% level

Inspection of results indicates that ex post awareness levels about H2-powered vehicles are significantly higher than ex ante knowledge levels in Perth only. As noted in previous sections, this is likely to be a direct consequence of the extensive and concerted information campaign in this city. London on the other hand engaged in no such information campaign.

Otherwise, results in Table 22 indicate that the likelihood of knowing about H2 vehicles in both cities is determined by very similar variables: thus, older male university-educated respondents with higher incomes are more likely to know about H2 vehicles. Additionally, knowledge tends to be higher amongst respondents with greater environmental knowledge (those who disagree with the statement: "*The main cause of global warming is the hole in the ozone layer"*).

However, a major difference between the models for London and Perth is the influence of the variables ENVATT and TECHNATT. In London, knowledge about hydrogen is more likely amongst respondents with a more 'techno-centric' outlook (Dunlap and Van Liere, 1978), as indicated by agreement with the statement: "*Science and technology are the key to solving environmental problems"*. In Perth, on the other hand, knowledge about hydrogen is higher amongst people with general environmental attitudes (as indicated by agreement with the statement "*Solving environmental problems should be one of the top 3 priorities for public spending"*. In addition, bus users are significantly more likely to know about hydrogen in London only.

These results confirm the findings reported in Section 5.1 (Table 14) for bus users only, that knowledge has increased in Perth whilst there has been no change in London.

A logit regression on the dummy variable representing unconditional support for the large-scale introduction of H2 buses was carried out on the whole London and Perth samples. Results confirm findings in Section 5.2 for bus users only, that ex post support has increased significantly in both cities. In Perth, it can be observed that prior knowledge about hydrogen is a significant driver for unconditional support; however, as in Section 5.2, there has been a significant increase in support independent of changes in knowledge (this is also the case for London). This suggests that some other factor has changed that has not been picked up by the regressions. As proposed in Section 5.2, such factors might include: increased concerns about climate change or air pollution impacts in general, associated with increased media attention to these issues. This would be an area that would benefit from future research.

Finally, it is also interesting to note that repeat respondents in the London ex post sample appear to be less likely to unconditionally support the introduction of H2 buses in the city, which contrasts with the increased WTP statistics reported in Tables 21 and 22. However, this influence is only significant at the 10% level.

Table 23: Pooled model results: logit regression on SUPPH2BUS for London and Perth

	London			Perth		
	coefficient		t-ratio	coefficient		t-ratio
YADJ	-0.027		-0.86	0.008		0.24
MALE	0.182		1.00	-0.052		-0.25
AGE	-0.012	*	-1.71	-0.015	**	-2.37
UNIVEDUC	-0.202		-1.10	-0.256		-1.20
ENVATT1	0.341	***	3.34	0.393	***	3.11
ENVATT5	0.145		1.47	0.086		0.72
ENVKNOW1	0.022		0.24	0.140		1.31
ENVKNOW2	0.076		0.79	0.153		1.42
H2KNOW	0.128		0.67	0.800	***	3.73
USEDH2BUS	-0.172		-0.23	0.583		0.92
REPEAT	-0.543	*	-1.76	-		-
BUSUSER	0.174		0.81	0.135		0.68
EXPOST	1.272	***	6.20	0.548	***	2.81
Constant	-2.039	***	-2.92	-3.368	***	-3.74
Pseudo-R2	0.08			0.08		
Chi2 (dof)	(13) 65.97			(12) 55.23		
No. of observations	621			533		

* Significant at 10% level, ** at 5% level, *** at 1% level

In order to assess whether these increases in unconditional support are matched by increases in WTP, an interval regression was carried out on WTP_X values. Results, presented in Table 24, show that there has been a significant increase in WTP_X in Perth since the H2 bus trial, although this is only significant at the 10% level. There has been no such increase in London.

It is perhaps interesting to note that prior knowledge about hydrogen has no influence on WTP_X in either city (despite being a positive influence on unconditional support for H2 buses in Perth). Rather, environmental attitude and income appear to be the key drivers of

$WTP_{X,}$ as expected (university education is also an influence in Perth, and gender is an influence in London).

Table 24: Results of Interval Regressions on WTP_X (bus users and non-bus users)

	London (WTP_X)		Perth (WTP_X)	
	coefficient	t-ratio	coefficient	t-ratio
YADJ	3.495 ***	3.01	2.089 ***	5.22
MALE	8.215 *	1.7	-2.740	-0.9
AGE	0.113	0.76	0.103	1.07
UNIVEDUC	-0.404	-0.09	5.991 **	2.06
ENVATT	6.024 **	2.22	5.215 ***	2.92
BUSUSER	6.575	1.32	-0.936	-0.33
H2KNOW	1.270	0.25	3.394	1.14
USEDH2BUS	-9.493	-0.91	1.798	0.18
REPEAT	16.894	1.53	-	-
EXPOST	1.874	0.41	5.003 *	1.87
Constant	-24.435	-1.33	-14.139	-1.37
Sigma	43.42		24.26	
Log pseudo-likelihood	-1645.72		-1112.95	
Prob>chi2	0.001		0.000	
No. of observations	380		322	

* Significant at 10% level, ** at 5% level, *** at 1% level

In addition, repeat respondents are not willing to pay more in London, indicating that the higher economic estimates presented in Tables 21 and 22, simply reflected the different socio-economic or attitudinal characteristics of repeat respondents.

Overall, these results confirm and add to the econometric results for bus users only, presented in Section 5 of this report.

7. CONCLUSIONS

The AcceptH2 project aimed to assess existing public awareness, acceptability and preferences associated with H2 FC buses in five cities across the world, and the impacts of H2 bus trials taking place in each of the cities involved, on these factors. This is the first large-scale quantitative investigation of awareness, acceptability and preferences associated with hydrogen technologies, and is therefore a significant contribution to the existing empirical data.

Overall, results from these survey studies support findings in the existing empirical literature that the public is not particularly concerned about hydrogen. There has long been a perception amongst experts and decision-makers in the field of hydrogen technology, that the public might reject new H2 technologies due to associations with the Hindenburg, hydrogen bomb or other explosive connotation. In fact, results from this study have shown that, when respondents were asked to provide spontaneous associations with the word 'hydrogen', on the whole, negative associations (e.g. 'bomb', 'Hindenburg', 'explosions') were less frequent than expected, and most associations given could be classed as *neutral* (e.g. 'gas', 'peroxide', 'fuel'). These results broadly support findings in the studies by Dinse (1999) and Altmann and Graesel (1998), where negative associations were mentioned with less frequency than neutral or positive associations.

The existing literature also reports quite high levels of acceptance for H2 transport and low perceptions of risk from hydrogen. For example, Altmann and Graesel (1999) reported a high level of acceptance of H2 buses amongst respondents in Munich, and found that public perceptions of risk from hydrogen were low. Similarly, safety was not an issue amongst taxi drivers in Mourato et al (2004). These findings are similar to those produced in this project, where concerns did not emerge as a major factor influencing attitudes to hydrogen.

Likewise, the analysis also supports past findings that on the whole, acceptability is associated with prior knowledge (e.g. Mourato et al, 2004; Lossen, 2003; Dinse, 1999; Altmann and Graesel, 1998). Although it is clear that respondents must have prior knowledge in order to have an opinion, the fact that the stated attitudes are positive rather than negative most likely reflects the nature of the information that is currently publicly available (O'Garra et al, 2005). One of the key determinants of attitudes is information (Eagly and Chaiken, 1993); thus positive information is more likely to generate a positive attitude, whilst negative information is more likely to generate a negative attitude towards the attitude-object. It is suggested therefore that most publicly available information on hydrogen has been largely positive. If indeed, the publicly available information were mostly negative, support levels may be lower.

This project has also added significantly to the existing evidence regarding economic values associated with H2 transport. The only study to assess preferences, by Mourato et al (2004), found that taxi drivers are willing to pay to drive H2 FC taxis, and that WTP is determined by expectations of financial gain in the short-term, and environmental concerns as well, in the long-term. The current project found that the public is also willing to pay to support the large-scale introduction of H2 buses in their respective cities, and that drivers for WTP are different for different countries.

However, results from this project do not support findings in the study by Altmann and Graesel (1998) that direct experience of H2 transport positively influences acceptability; findings in this project indicate that, on the whole, respondents who had used a H2 bus or respondents who were interviewed on-board a H2 bus, were no more likely to support their large-scale introduction than respondents who had never used, or heard of, the H2 buses being trialled in each city. This finding would benefit from further analysis to explore the reasons why direct experience has not had the expected positive influence on acceptability or WTP for H2 buses.

Additionally, in contrast to the wider existing empirical literature on acceptability and preferences for environmental transport technologies, environmental concerns do appear

to play an important role in determining acceptability and WTP for H2 buses in many cases. For example, agreement with the statement "*Solving environmental problems should be one of the top 3 priorities for public spending in [city]"* is found to be a key driver for unconditional support for H2 buses in London and Berlin, and a key driver for WTP for the large-scale introduction of H2 buses in London and Perth (although no such relationship between environmental attitude and acceptability or WTP was identified for the Luxembourg samples). Findings in the literature, on the other hand, indicate that on the whole, environmental concerns are not key determinants in the choice of transport technologies (e.g. Altmann and Graesel, 1998 Ewing and Sarigollu, 1998; Kurani, 1996; Segal, 1995).

It is suggested that, on the basis of findings from the current study, the relationship between environmental attitudes and the choice of transport technology may be a function of geographical location (and associated cultural, educational, informational and social differences). Thus in some cities, such as London, environmental issues might be prominent in people's transport-related decisions whilst in other cities, such as Luxembourg, environmental attitudes may have no such influence. Notably, most of the empirical literature into acceptability and preferences for cleaner transport technologies is U.S.-based and hence the lack of influence of environmental concerns on transport-related decisions may simply be a function of the geographical location. This would require further research to investigate whether this is indeed the case.

This project has also assessed the relative impact of the H2 bus demonstration projects in each city in raising awareness and creating positive acceptance of hydrogen transport. This is the first study to investigate the relative effectiveness of H2 demonstration projects in these respects, and so represents a significant contribution to the empirical literature.

Overall, results indicate that the impacts of the H2 bus trials have included:

1) Increased awareness about H2-powered vehicles amongst respondents in Luxembourg and Perth only.
2) Increased unconditional support for the large-scale introduction of H2 buses in all cities involved (except Oakland, which did not carry out the ex post study).
3) Almost no impact on WTP for the large-scale introduction of H2 buses in each city, except:
    a. In Luxembourg, where there is an increased WTP extra annual tax, but no change in WTP extra bus fare.
    b. In Berlin, where there is an increased WTP extra annual tax only (but only significant at the 10% level).
    c. In Perth (whole sample) where there is an increased WTP extra annual tax only (but only significant at the 10% level).

Furthermore, awareness about the H2 bus trials was highest in Perth (57% of bus users 54% of non-bus users had heard about the bus trial), followed closely by Luxembourg (51% of bus users had heard about it). Conversely, in London, only a 20% of bus users and 15% of non-bus users were aware of these trials.

It is evident from these results that the H2 bus trials have been more effective in raising public awareness in Perth and Luxembourg, compared to Berlin and London. Although it is evident that three H2 buses will be more visible in smaller cities such as Luxembourg (population 450,000) or Perth (population 1.5m), compared to larger cities such as London (population just under 8m) or Berlin (population 4.5m), it is suggested that the different levels of influence of the H2 bus trials on bus user awareness in each city also reflects the extent of public outreach and information campaigns that accompanied these demonstration projects.

In Perth, in particular, there has been an extensive public dissemination campaign associated with this trial, involving brochures, school visits, TV programmes, a dedicated website, conferences and various radio interviews. Luxembourg also made radio commercials when the buses arrived, and more than 1,000 persons took part in dedicated

guided tours during the first six months of the Luxembourg bus trial alone. In contrast, in London only a handful of articles about the bus trials were published in the media; in Berlin, as noted, the trial involved one bus only operating for about 6 months, and very limited media attention.

On the basis of these results, it is suggested that the effectiveness of the H2 bus demonstration projects is a function of two key factors:

1. The extent to which the public has been engaged via information and communication campaigns.
2. The relative exposure of the buses, which is in direct proportion to the size of the cities.

Furthermore, there appears to be an increase in unconditional support in all cities, and an increase in WTP in Luxembourg (taxes only) - and Perth and Berlin (at 10% level) - that has not been explained by any of the socio-economic or attitudinal variables included in the regressions. This suggests that some other factor has changed, which has led individuals to value H2 buses more, *ex post*. This could include:

1. Changed attitudes to new environmental technologies
2. Changed attitudes to climate change
3. Changed attitudes to transport and emissions.

These are areas that would benefit from future research.

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