CHIC

Clean **H**ydrogen **I**n European **C**ities

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Influencing factors to the acceptance process of FCH technologies in public transport (CHIC project)

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0. Executive summary

This report summarises the main results from the CHIC research on social acceptance of FCH buses and hydrogen technologies. The CHIC research approach has as its starting point the findings of former studies on acceptance indicating a generally positive attitude towards hydrogen and hydrogen technologies in society, but revealing a considerable lack of information/ knowledge on the topic among the general public. The acceptance of FCH buses and hydrogen technologies in the group of stakeholders, responsible for and involved in demonstrating these technologies, had only been partially researched previously. The CHIC research on acceptance aimed at closing this gap and including stakeholders as well as citizens in the research on acceptance of FCH buses in public transport. The qualitative research approach used is based upon the understanding that acceptance is a process, dependent on several influencing factors and changing over time. In total 185 face-to-face, one-hour interviews in five of the CHIC regions (Aargau, Bolzano, region of Cologne, Hamburg, and Oslo) were conducted between August 2011 and March 2013. In order to identify influencing factors to the acceptance, most interview regions were visited twice, before and after the start of operating the buses and the refuelling station. Interview partners were bus drivers, citizens / passengers, regional project partners and stakeholders, and CHIC partners.

Acceptance is a process that can be shaped

This report is about people rather than technology. It is about understanding why individuals take responsibility, accept additional work load and cost, and commit to a vision that still has to be proven in everyday life. It is about understanding what obstacles and support they experience in bringing change to “a running system”, when they undertake to demonstrate innovative technologies in competition to existing, well accepted alternatives. It is also about feedback on and expectations of technology performance and overall system design, in order to secure acceptance today and in the future. The results of the CHIC research on social acceptance clearly demonstrate that acceptance of FCH buses and technologies is a process, dependent upon a mix of project, technology and regional contexts and changing over time.

Bus drivers identified significant improvements to the bus characteristics and criticized reliability

The overall acceptance of the project initiative and the hydrogen technologies in the group of bus drivers was generally supportive and/or tolerant, but already eroding at the times of the interviews. However, the driving comfort of the electric drive and the project “vision” convinced people and appeared to make up for set-backs in reliability and performance.

The bus drivers had supported the project initiative from the beginning; a key factor in their acceptance was the objective of reducing the environmental impacts of transport. Opinions of the FCH buses themselves and the project implementation processes showed more ambivalence and the experiences with the technology and the project aggravated this ambivalence: On the one hand smooth driving and a reduction of noise surprised and enthused the bus drivers and increased acceptance. On the other hand, non-hydrogen related problems, the reliability of the technologies, unsatisfying information flows (feedback), and the amount of time to fix problems challenged acceptance. "On-the-line" outages, failures and a lack of expertise to respond to passengers' questions were perceived as being embarrassing situations in a very public work environment, and resulted in decreased acceptance.

Bus drivers who expected the project to be a trial rather than a market entrance activity seemed to be less frustrated or disappointed with problems and outages, and showed more positive acceptance levels throughout the project.

The general public is mostly unaware of the potential of the technology

The project initiative was clearly supported by the citizens interviewed. They appreciated that "finally somebody is taking action for the environment". However, the awareness about the initiative as well as the potential of the technology was generally low, although the FCH buses had been noticed.

Passengers and citizens clearly stated that the priority role for public transport services should remain securing a high quality of public transport services. As several challenges to the local or regional public transport systems were already being experienced or were envisaged (e.g. increase in demand resulting in service shortages, tardiness, perceived increased safety issues either with other passengers or with public transport infrastructure, transport services to and in suburban or remote areas), any activities other than the core activities did not seem to be of particular interest to the general public interviewees. At most, people showed appreciation of the potential future environmental benefits of the use of FCH buses in public transport and the "noble" goals of the project initiative. Changes to the bus technology seemed to be generally less influential in shaping public opinion than changes to processes and services directly impacting passengers. Thus changes to the bus technology resulting in any reduction in the quality of bus services can reasonably be assumed to decrease acceptance significantly.

The stakeholders are supportive but await the outcome of the project before final evaluation

The results of the interviews indicate that project partners and stakeholders in the project environment evaluated experiences and technology performance relative to their prior expectations. The expectations of stakeholders were strongly influenced by the CHIC project framing or the regional framing of the project ("story"). Some central expectations seemed to not have yet been fulfilled at the times of the interviews, and although interviewees explicitly stated that this hadn't resulted in a decrease of technology or project acceptance so far, it was obvious that they were expecting the fulfilment of their expectations by the end of the project. The final evaluation would then be the basis for decisions on further commitment and support. The influence of expectations and of technology and project framing on the acceptance of stakeholders can be summarized to be potentially strong but without significant impact at the time of the interviews due to the interviewees' benevolent attitude. This attitude could be interpreted as a "vote for confidence", based upon the technology concept and the regional framing ("story").

"Value for money" is key to the acceptance process

The motivation of the people involved in the demonstration of FCH technologies together with the views of the general public as shared in the research interviews revealed the need for further added value other than climate protection in order for these groups to accept fundamental changes in the public transport system. Such additional benefits of the use of FCH buses in public transport were identified being

- improvements to the work environment for bus drivers
- improved local air quality and reduction of noise levels
- improved quality of bus services to the passengers (smoother riding)
- long-term security of energy supply

Public or government fleets might thus be important first users for the FCH technologies

These additional benefits as well as expected benefits to the region and/or the environment seem to strongly and positively influence acceptance in the demonstration phase. The more these benefits are perceived for the local or individual situation, the greater the acceptance. Public or government fleets might thus be important first users for the FCH technologies, as these owners join three different interests: the employer perspective (improvements to the work environment), the political/ societal perspective (clean and quiet transport, climate protection) and the entrepreneur perspective (securing long term goals of fuel supply). Critics and

sceptics mainly questioned the potential environmental benefits and the "value for money" of FCH technologies in respect to climate change mitigation and regional development compared to other (technology) solutions and activities. Allocation of resources and public funds seemed to be a central issue in some of the regions.

Acknowledgement

The authors thank the regional partners who helped organise the interviews, all interviewees for their frank and honest cooperation, and the CHIC project and FCH JU enabling this new approach to social research on the acceptance process of FCH technologies.

All information provided in this report is based upon interviews, and reflect the personal experiences and professional evaluation of the interviewees.

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List of abbreviations

FCH-JU	Fuel Cell and Hydrogen Joint Undertaking
EU	European Union
CHIC	EU-funded project "Clean Hydrogen in European Cities"
ESTEEM	The ESTEEM tool is an outcome of a European Research Project called Create Acceptance (EU/DG Energy/FP7 Contract n° 518351 see http://www.createacceptance.net)
H_2	Hydrogen
WP	Work package
FCH	Fuel cell and hydrogen, fuel cell hybrid
HRS	Hydrogen refuelling station

1. Objective(s) of the report

This report summarizes the methodology and findings of social research on acceptance for the FCH-JU funded hydrogen bus project "CHIC – Clean Hydrogen in European Cities" (2010-2016). The 185 qualitative interviews with selected project partners, regional stakeholders and the general public in Bolzano (Italy), Brugg (Switzerland), Hamburg (Germany), Huerth/ Bruehl (Germany, Cologne region), and Oslo (Norway) were conducted from 2011 to 2013 and reflect the situation during the implementation and demonstration phase of hydrogen buses in public transport. Only Hamburg and Huerth/ Bruehl (Cologne region) had had longer experience with hydrogen and the operation of hydrogen buses at the time of interviews.

The report aims at presenting the diverse opinions and concerns of the people involved – both directly in the project and also in the regional processes that took place in order to demonstrate hydrogen buses in public transport.

2. Readers' guide

This report is structured in three parts:

Chapter 3 explains the theoretical background and the methodological approach to the CHIC social research. The CHIC project, the interview regions as well as the sample of interviewees are described.

Chapters 4-6 focus on the views, acceptance levels and influencing factors in the acceptance process of the three target groups: bus drivers, stakeholders (core project partners and regional project environment) and the general public. They provide a **detailed insight into the project process and the technology implementation in the regions** and report on feedback provided by the interviewees. Within each chapter the acceptance level at the time of the interviews is described first, followed by an analysis of potential consequences to the acceptance process. Each chapter is summarized by drawing preliminary conclusions.

Chapter 7 integrates the **main findings in an overall perspective**, providing information on lessons learned from the project and the technology implementation processes. It focuses on reflecting and understanding the acceptance process and its implications for on-going CHIC project activities. It is expected that this chapter will be of help to other on-going or future FCH and hydrogen demonstration projects, and provides an overview for readers with limited time and/ or who are not interested in the details of the analysis.

All chapters can be read as stand-alone. For a better understanding it is recommended that all chapters are read.

3. The CHIC social research approach

3.1. Objectives

When the CHIC project started in 2010, previous research on social acceptance of FCH technologies in transport had revealed a generally positive and open minded attitude in the general public[1]. In contrast to some other contemporary innovations e.g. green genetics and nanotechnologies, hydrogen applications appeared not to unduly concern people. However, up until this point, stakeholders responsible for planning, implementing and operating hydrogen applications had not been the focus of social acceptance studies (with the exception of some user acceptance analyses).

A major shortcoming of previous studies of people's attitudes was that those interviewed, in most cases, had only a limited awareness and understanding of the technology itself and/or the impact the implementation of the technology system might have on them. **The CHIC-approach therefore aimed to extend the existing knowledge about the state of technology acceptance by identifying drivers to the acceptance process itself**, shedding light on the reservations/concerns of different stakeholders such as environmental groups, industry, government and political decision-makers, and providing the necessary background information to understand acceptance rather than measuring it.

Spilett n/t is a project partner in CHIC, being responsible for the social research task 3.5 in work package 3. From 2010 to 2013, Spilett not only conducted interviews in five selected interview regions, but also participated as a project partner in the project meetings.

The social research work was funded by the EU initiative on hydrogen and fuel cells FCH-JU (Fuel Cell and Hydrogen Joint Undertaking).

1 "What do we know about public perceptions and acceptance of hydrogen? A critical review and new case study evidence", Miriam Ricci et al, International Journal of Hydrogen Energy 33 (2008) 5868-5880

3.2. The CHIC project

3.2.1. Project description

The project communication work package provided background information on the project to be used for regional communication. The CHIC brochure summarized the main characteristics, goals and motivation of the project as follows[2]:

"The CHIC project aims at providing results from demonstrations of more than 55 hydrogen buses. Of these, 26 Fuel Cell Hydrogen (FCH) buses are directly funded by the European Union Joint Undertaking for Fuel Cells and Hydrogen (FCH JU) and will operate in daily public transport operations in five locations across Europe- Aargau, Bolzano/ Bozen, London, Milan, and Oslo. The CHIC project is supported by the FCH JU with funding of 26 million Euros, and has 25 partners from across Europe, which include industrial partners for vehicle supply and refuelling infrastructure. The project is based on a staged introduction and build-up of FCH bus fleets, the supporting hydrogen refuelling stations and infrastructure in order to facilitate the smooth integration of the FCH buses into Europe's public transport system. The buses in the CHIC project are supplied by three different manufacturers and the hydrogen refuelling infrastructure involves the industrial players active in hydrogen infrastructure development around the world. An important part of the project is to assess the environmental, economic and social impacts of the use of hydrogen powered buses. Hydrogen can be produced by different methods, including using renewable energy. Fuel cells use hydrogen to generate electricity while emitting only water vapour.

The CHIC project forges partnerships with similar projects in Berlin, Cologne, Hamburg and Whistler (Canada), which have previously gained experience with perating 34 hydrogen powered buses and 14 new cities and regions in Europe which are considering moving into the field. These partnerships will facilitate the effective and smooth introduction and expansion of the new systems now and into the future.

Hydrogen and fuel cells can therefore play an important role in the reduction of local air pollutants, as well as in the decarbonisation of Europe's transport system. Hydrogen powered transport has the potential to meet operational requirements of buses, light passenger, and commercial vehicles without generating the harmful emissions and noise of conventional fuels. The objectives of CHIC project are to tackle the remaining obstacles the technology faces and move these demonstration vehicles to commercialization starting in 2017."

The CHIC project started in 2010 and will run until 2016.

2 Source: CHIC Brochure, English version, downloaded at the project webpage on June 12th, 2013

3.2.2. The CHIC structures and processes

The CHIC project was implemented in regions both with prior experiences and on-going activities (called: phase 0 cities) in hydrogen technology and also in regions without prior experiences (called: phase 1 cities). The demonstration activities of the FCH buses and the hydrogen stations had to be integrated into existing regional strategies and structures, including regional stakeholders (project environment). The research on acceptance in the CHIC project considered the enlarged CHIC-project, including the regional project environment as presented in Figure 2.

The overlapping structures of the CHIC project, regional hydrogen activities (strategies, projects, networks), and the regional context of public transport and infrastructure resulted in both vertical and horizontal working structures:

- The **regional stakeholders who were also partners in the CHIC** project became the interface of the CHIC activities in the regions, some of them being responsible for coordination of interests and activities. They reported on the project progress in the regions and also to CHIC, and had to integrate CHIC project related requirements (time schedules, cost, reporting) into the regional structures.

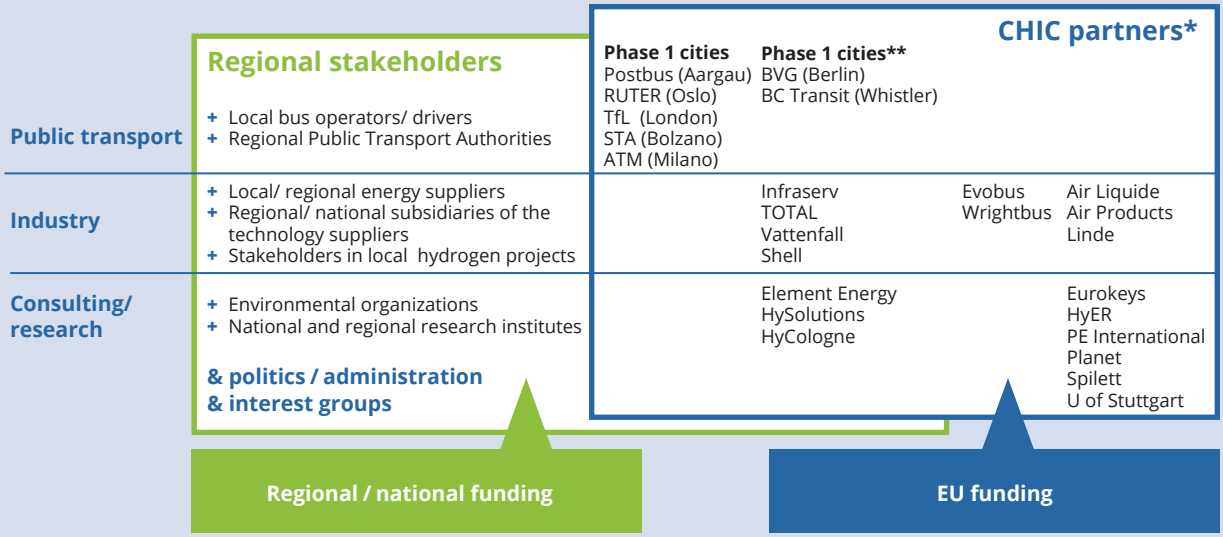
- The **regional stakeholders who weren't CHIC partners** worked on the regional level, without direct contact to the international CHI.C project or the regional stakeholders in other regions. Some of the regional stakeholders were networked to other regional stakeholders or CHIC partners outside the CHIC project.

- A few technology suppliers were neither CHIC partner nor regional stakeholders (as a result of the tendering process). These suppliers only worked on a regional level without direct interaction with the CHIC project.

- Most of the regional stakeholders can be interpreted as the (potential, future) **demand side** – either using, operating or funding hydrogen technologies

- The CHIC partners who were not regional stakeholders can be categorized as either the **supply side** or providing analytical, scientific or organizational services to the project. Some of the technology partners are also suppliers to the regions.

Figure 1: Overview of CHIC partners and regional stakeholders



** Some of the CHIC partners are also technology suppliers to the regions*
*** Some of the CHIC partners only received regional / national funding for the demonstration of hydrogen technologies in public transport*

Under the CHIC framework, the public transport authorities were responsible for tendering for HFC buses and hydrogen infrastructure, in addition some of the regions tendered bus operations due to local requirements. The information exchange on technology performance and project progress (reporting) happened in several ways:

+ **Reports** The CHIC project defined reporting contents and procedures to collect information on a monthly base (by email).

+ **Meetings** In bi-annual meetings, all CHIC partners met for an update on project progress and discussion on problems (face-to-face).

+ **Working groups** Working groups were set up to allow for a more frequent exchange of information (telephone conferences), on an “as needed” basis.

3.3. Theoretical background

3.3.1. Definition of acceptance in CHIC

Extensive research on the state of acceptance of and awareness about hydrogen energy and FCH technologies has been undertaken in the past. However, analyses of the acceptance process, identifying and understanding the dynamics as well as the factors influencing expectations and attitudes, had been rare when the CHIC project started.

The CHIC research approach therefore was based upon the following understanding of acceptance:

Acceptance is an aggregated term comprising different levels, objects, and owners of acceptance. Each of the acceptance values might change with time, resulting in an acceptance process that is actively or passively influenced by regional context, project structures and processes, and participating people.

Acceptance values investigated in this CHIC research are

- **Levels of acceptance** negative acceptance (refusing, criticizing), neutral acceptance (tolerating), positive acceptance (agreeing, supporting)
- **Objects of acceptance: What has to be accepted?** Project idea/ technology potential, technology characteristics, technology performance, project structures and processes
- **Owners of acceptance: Who has to accept?** Stakeholders in the core project, the project environment, and the general public

3.3.2. Acceptance levels: The characteristics approach

The **characteristics approach** developed by Kelvin John Lancaster in 1966 modified microeconomic demand theory and thus the understanding of consumers' behaviour and acceptance by shifting the focus from the good itself to the bundle of characteristics that are represented by the good (objects of acceptance). According to this approach *"goods in combination may possess characteristics different from those pertaining to the goods separately"*[3]. Applying these findings to a broad scale introduction of hydrogen powered buses in public transport, people may consider three "goods" or three objects of acceptance – public transport, hydrogen as a fuel, and renewable energies as an energy source – in deciding whether or not to accept the technology. Along with the characteristics associated with each of the goods, the characteristics of the implementation processes along with the technology characteristics can be expected to significantly influence decision making when comparing it to alternatives.

3.3.3. Acceptance process: The 7+ parameter approach

The core of the CHIC social research methodology is the **Seven(+)-Parameter-Approach**[4] bundling concepts and learning from change management theory, decision making analysis and marketing sciences to help analyse and understand the acceptance process. In this approach, change to levels of acceptance can be induced by:

Table 1: The Seven (+) Parameter Approach

Parameter: Habits	People tend to stick to the status quo especially in situations of uncertainty (the gains of alternative are not easy to understand), due to loss aversion (potential losses from switching are weighted as larger than potential gains, also known as endowment effect), or to "justify previous decisions and commitments to a (perhaps failing) course of action by making subsequent commitments"[5] (also called: status quo bias)

3 Source: „A new approach to consumer theory", Kelvin John Lancaster/ John Hopkins University in: The Journal of Political Economy,Vol. 74, No. 2 (Apr., 1966), pp. 132-157

4 CHIC public report no. D 3.3 "Concept for social research approach", N. Hoelzinger et al. 2011, Grant agreement No: 256848

5 "Status quo bias in decision making", William Samuelson (Boston University)/ Richard Zeckhauser (Harvard University), in: Journal of Risk and Uncertainty, 1: 7-59 (1988), Kluwer Academic Publishers, Boston

Parameter: Expectations

The implications of disappointment in decision making under uncertainty was first researched by David E. Bell and influenced the understanding of utility theory by introducing psychological satisfaction as a factor for decision making[6]: People's preferences

between two options with the same outcome will differ depending upon their prior expectation of the outcome. They would prefer the option with the bad outcome if they expected a worse outcome to the option with the good outcome if they expected an even better outcome.

Parameter: Visibility

Heuristics (i.e. "rules of thumb") determine intuitive decision making under uncertainty[7] of even well informed people leading to biased outcomes and systematic but predictable errors. Heuristics is used by every individual to filter information and find short cuts for decision making in complex situations. As people always use heuristics in decision making, they are likely to include experiences (either first or second hand) resulting from the past visibility of the subject into their decision processes.

Parameter: Level of knowledge

People tend to search, interpret and recall information supporting existing beliefs[8]. Once an opinion is formed, it is difficult to be changed by arguments. On the other hand, people spontaneously confronted with a subject/ new information are likely to accept and internalize the information they first obtain (confirmation bias).

Parameter: Participation

The participatory approach was originally developed and applied in political systems and in organizations as a leadership strategy to motivate employees and democratize decisions. The positive influence of participation processes on acceptance is well known and researched, and several methodologies exist for participation in political and/ or legislative decision making. The integration of customer perspectives into the innovation process up to the integration of customer developed solutions into the product and/ or service has increased in quantity and importance in the past decade[9]. Meanwhile, social media has brought new dimensions to grass roots journalism, leading to an increased integration of the individual, public and/ or customer view into the decision making processes[10].

6 "Disappointment in Decision Making under Uncertainty", David E. Bell (Harvard University), in: Operations Research, Volume 33, Issue 1 (Jan-Feb 1985), 1-27
7 "Judgment under Uncertainty: Heuristics and Biases", Amos Tversky/ Daniel Kahneman (Hebrew University, Jerusalem), in: Science, vol. 185, p.1124-1130 (1974)
8 "Confirmation Bias: A Ubiquitous Phenomenon in Many Guises", Raymond S. Nickerson (Tuft University), in: Review of General Psychology (1998), Vol. 2 Nr. 2, p.175-220
9 "Democratizing innovation", Eric von Hippel (2005), Creative Commons, in: http://web.mit.edu/evhippel/www/democ1.htm
10 "We media – how audiences are shaping the future of news and information", Shayne Bowman/ Chris Willis (The Media Centre at the American Press Institute), in: http://www.hypergene.net/wemedia/, 2003

Parameter: Level of impact

The **NIMBY-principle ("Not In My Back Yard")** indicates that people oppose changes that lead to an impact in their close neighborhood or social environment (life).

The **free rider problem** is well known in environmental sciences and economics: An individual may benefit from a good without contributing to the cost, or vice versa be negatively impacted by the use of an innovation system (side-effects of the innovation itself), while benefitting less or equally from the innovation compared to other individuals. The acceptance of the innovation in its system's context might be reduced due to the negative system side-effects of the innovation.

Parameter: Life Style

Lifestyle as a social concept can be investigated in three dimensions[11]: values people express (in basic dimensions, as freedom, justice etc.); clusters of attitudes, opinions, interests and activities; actual patterns of behavior (political engagement, membership in sports clubs etc.). Although different lifestyle concepts are widely used and accepted in marketing, as well as in social research into hydrogen acceptance, the significance of lifestyle influences on acceptance when compared to other variables is still under discussion.

Parameter: Context

Acceptance as a result of expectations, experiences and motivation requires a supportive environment, allowing for testing, failing, optimizing and rethinking strategies and technology concepts. It is essential that the technologies and strategies are embedded into the regional and organizational context, and do not have to compete/ succeeding too early in a competitive environment. The acceptance of an idea or a technology system might be influenced by the context more than the underlying technology performance.

This theoretical background was used to design the CHIC interview guidelines and evaluate the results. To increase the reader-friendliness of the report, the theories have been integrated into the four topic areas of

- Regional context
- Technology potential
- Technology characteristics and performance
- Project structures and processes

11 „Lifestyles, and Risk Perception Consumer Behavior", Lennart Sjöberg et al. (Stockholm School of Economics), in: International Review of Sociology, Vol. 15 No.2 (2005), p.327-362

3.4. Methodology

The objectives of the research approach in CHIC are to understand the level of acceptance and the factors influencing the acceptance process of FCH technologies in public transport. The research design therefore focused on comparative, qualitative interviews and included a

- **comparison of regions:** The regional implementation of the CHIC project allowed for conclusions on the overarching patterns of acceptance. Due to the size of samples, the results cannot be interpreted as being valid for hydrogen projects in general, but allow for a better understanding of acceptance in CHIC. Due to confidentiality reasons, no detailed regional case studies have been reported.

- **evaluation over time:** The interviews in CHIC phase 1 regions were done at two different times in the implementation process – before the buses arrived and the infrastructure was built *(pre-test interviews)*, and after buses and HRS station were in operation *(post-test interviews)*. The acceptance process could thus be monitored and influencing factors identified and discussed.

3.4.1. Interview regions

Due to financial and practical considerations the research design did not envisage a complete analysis of all CHIC regions but selected five of the nine CHIC phase 0 and phase 1 regions for participation in the CHIC acceptance research. The decision to include phase 1 as well as phase 0 cities in the research design was based on the belief that there were differences in experiences during the hydrogen project implementation as well as in the local hydrogen project design. These differences could lead to differences in awareness and also the acceptance level of different stakeholder groups and the general public towards the use of hydrogen energy and FCH technologies in public transport.

Additionally, the CHIC phase 0 regions were considered as "senior partners" in the project, providing knowledge and sharing experiences with the phase 1 cities. The diverse funding arrangements applied in these regions were expected to also provide insight into the influencing factors on the acceptance process related to funding process and design. *The states of project implementation at the times of the interviews are shown in Table 2*.

The technologies demonstrated in the CHIC interview regions are **fuel cell hybrid buses** from three different bus suppliers (Evobus, Van Hool and APTS) and HRS stations from five different suppliers/ operators (Air Liquide, Air Products, Carbagas, Vattenfall, Linde). Between two and five buses were demonstrated at each site, making up to 20% of the local fleet at the bus depot. The buses ran on electricity generated through a hydrogen fed fuel cell or recuperated during operation (braking energy). The hybridization of the electric drives was supported by an energy management system and software, including batteries and capacitors for the storage of electricity. The buses were operated to be refuelled once a day in all interview regions (usually in the evening and / or during the night). *The bus and HRS station technology concept are shown in Table 3.*

Table 2: Interview regions and times

	State of the project at		
		FCH Buses	**HRS hydrogen station**
Pre-test interviews *(29/09/11 – 23/01/13)*	Bolzano (I)	Before arrival	Under construction
	Brugg (CH)	Before arrival	Before build-up
	Hamburg (DE)	Only post-test situation (phase 0 region)	
	Huerth/ Bruehl (DE)	Only post-test situation (phase 0 region)	
	Oslo (NO)	Before arrival	Under construction
Post-test / citizens interviews *(21/05/12 – 01/03/13)*	Bolzano (I)	Only pre-test situation	
	Brugg (CH)	Daily operation	Daily operation
	Hamburg (DE)	Daily operation	Daily operation
	Huerth/ Bruehl (DE)	Daily operation	Daily operation
	Oslo (NO)	Daily operation	Daily operation

Table 3: Overview on the technology concepts in the CHIC interview regions

Hydrogen buses

Bolzano (I)	Brugg (CH)	Hamburg (DE)	Huerth & Bruehl (DE, Cologne)	Oslo (NOR)
 ©Evobus	 ©PostAuto	 ©Hamburger Hochbahn	 ©RVK	 ©RUTER
Citaro Fuel Cell Hybrid (Evobus)			**Phileas Fuel Cell Hybrid Bus (APTS)**	**European Hybrid Fuel Cell Bus (Van Hool)**
Vehicle size (length x width x height) 11,95 x 2,55 x 3,50 m	Vehicle size (length x width x height) 11,95 x 2,55 x 3,50 m	Vehicle size (length x width x height) 11,95 x 2,55 x 3,50 m	Vehicle size (length x width x height) 18,5 x 2.55 x 3,20m	Vehicle size (length x width x height) 13,15 x 2,55 x 3,42m
Vehicle weight (empty / max.) 13,6 t / 19,0 t	Vehicle weight (empty / max.) 13,4 t / 18,0 t	Vehicle weight (empty / max.) 13,3 t / 18,0 t	Vehicle weight (empty / max.) 19t / 25,8 t	Vehicle weight (empty / max.) 16,9 t / 25,8 t
Passenger capacity Seats: 27 + driver 1 flip up seat, 1 wheel chair Standees: 44 Total: 71 + 1 flip up + 1 wheel chair + driver	Passenger capacity Seats: 30 + driver 2 flip up seats Standees: 33 Total: 63 + 2 flip ups + driver	Passenger capacity Seats: 27 + driver Standees: 42 Total: 69 + driver	Passenger capacity Seats: 38 + driver Standees: 57 Total: 95 + driver	Passenger capacity Seats: 37 + driver 2 flip up seats Standees: 37 Total: 74 + 2 flip ups + driver
Power plant (kW) NuCellSys, Dual-FCS 120 kW	Power plant (kW) NuCellSys, Dual-FCS 120 kW	Power plant (kW) NuCellSys, Dual-FCS 120 kW	Power plant (kW) Ballard FC Velocity HD6 150 kW	Power plant (kW) Ballard FC Velocity HD6 150 kW
Motor output 2 x 60 kW (cont.) 2 x 129 kW (max.)	Motor output 2 x 60 kW (cont.) 2 x 129 kW (max.)	Motor output 2 x 60 kW (cont.) 2 x 129 kW (max.)	Motor output 350 kW	Motor output 2 x 85 kW (cont.), 2 x 150 kW (max.)
H_2 storage capacity @350bar 35 kg	H_2 storage capacity @350bar 35 kg	H_2 storage capacity @350bar 35 kg	H_2 storage capacity @350bar 38 kg	H_2 storage capacity @350bar 35 kg
Hybrid drive batteries (capacity / max. power output) 26 kWh / 258 kW	Hybrid drive batteries (capacity / max. power output) 26 kWh / 258 kW	Hybrid drive batteries (capacity / max. power output) 26 kWh / 258 kW	Hybrid drive batteries (capacity / max. power output) 23 kWh (Hoppecke NiMH)	Hybrid drive batteries (capacity / max. power output) 17,4 kWh / 100 kW

Hydrogen stations

Bolzano (I)	Brugg (CH)	Hamburg (DE)	Huerth & Bruehl (DE, Cologne)	Oslo (NOR)
				
©ITT	©PostAuto	©Vattenfall	©HyCologne	©RUTER
ITT / Linde	**Carbagas**	**Vattenfall / Linde**	**Air Products / Infraserv**	**Air Liquide**
Location City of Bolzano	Location Hydrogen bus depot	Location City of Hamburg	Location City of Huerth (Region of Cologne)	Location Hydrogen bus depot
Hydrogen production Water electrolysis	Hydrogen production Water electrolysis	Hydrogen production Water electrolysis	Hydrogen production By product hydrogen (chlorine production)	Hydrogen production Water electrolysis
H_2 production capacity @day 400 kg	H_2 production capacity @day 60 Nm^3 / h 1.440 Nm^3 / day	H_2 production capacity @day 250 kg	H_2 production capacity @day No production on site, trucked in	H_2 production capacity @day 250 kg
H_2 storage capacity At least 3.000 Nm^3	H_2 storage capacity 5.000 Nm^3 @ 410 bar (12.360 liter)	H_2 storage capacity 250 kg @ low pressure, 500 kg@ high pressure	H_2 storage capacity 120 kg	H_2 storage capacity 340 kg
Back-up system Yes (delivery)	Back-up system Yes (delivery), Trailer with 3.600 nm^3 @ 200bar	Back-up system Yes (delivery), 2 redundant compressors	Back-up system Yes (delivery)	Back-up system Yes (delivery)

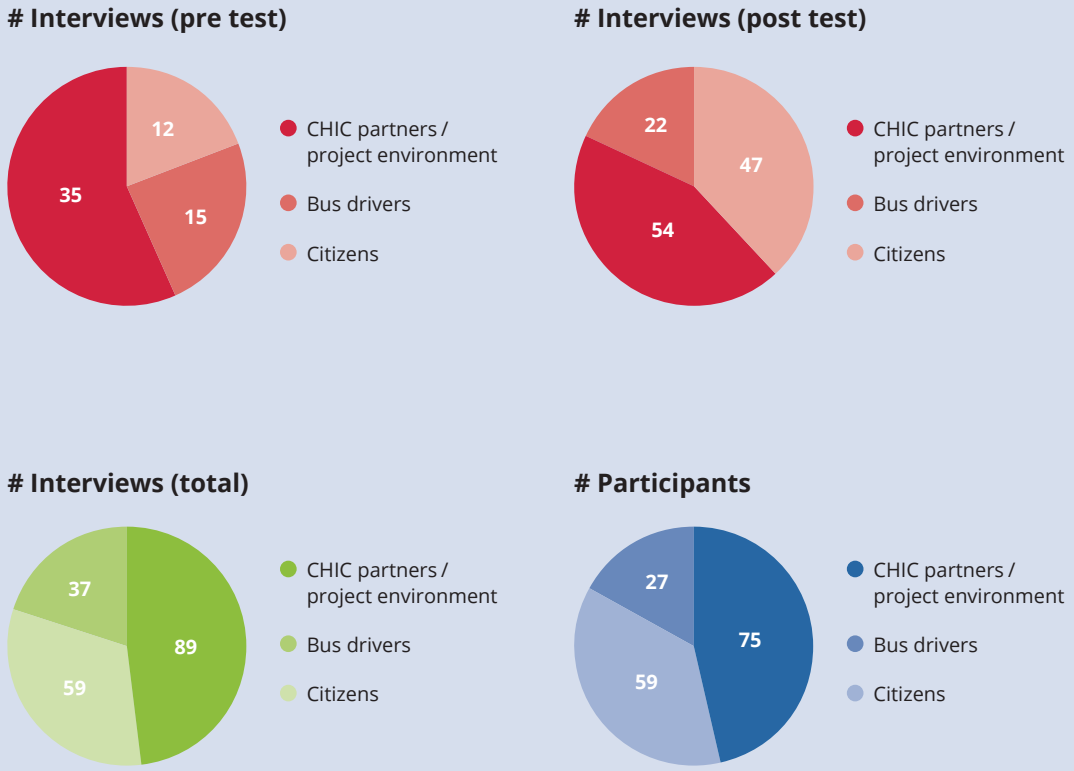
3.4.2. Data collection and evaluation

The qualitative research approach allowed for the identification and understanding of important and only partly known influencing factors on the acceptance process of the general public and selected stakeholders during the early implementation of this innovatory project. Due to funding restraints, the sample of interviewees did not include all people involved or impacted by the project in each region. Interviewees were selected to best reflect the current involvement of stakeholders and the general public, and provide a broad insight into several perspectives of the acceptance process. As long as hydrogen energy and FCH technology is still in its demonstration phase and not broadly introduced into society with standardized technology and administrative processes, people have to cope with transitional system boundaries. These include regional technology concepts and system performance, project implementation processes and development of suitable operation models. This means that conclusions drawn on the acceptance of FCH technologies in public transport are limited in their generalizability. Nevertheless, they do provide important insights about factors influencing acceptance in widely varying environments.

Data collection was based on qualitative interviews using a semi-structured interview guideline. The interview guideline was designed to provide topics to be addressed but leave open the focus of the interview, the succession of topics and the answers to questions. New topics could be brought in spontaneously by the interviewees according to their interests and need to consider new aspects and identify additional factors in the acceptance process.

The qualitative interviews were conducted face-to-face in the project regions whenever possible. Only three stakeholder interviews were done via telephone due to organisational reasons. Most of the interviews lasted between 45 and 90 minutes. A few of the interviews had to be restricted to 30 minutes due to time constraints of the interviewees. Table 4 provides an overview of the size and distribution of the interview sample used in this research. The difference in the number of interviews and the number of interviewees is explained by the fact, that some interviewees were interviewed twice, in a pre- and in a post-test interview approach.

Figure 2: Overview of interview samples (pre- and post-test)



The **CHIC project partners and the project environment** comprised regional stakeholders

- **in their role as** project initiators, project owners, project leaders, project partners and support roles such as (other) suppliers, consultancies, funding and approval authorities
- **working and being responsible** for the strategic planning or the operational implementation of the project and the technology
- **from the areas** of public transport, bus operators and fare networks, infrastructure and bus manufacturers, energy industry, research, interest groups, politics and administration, and the fire brigades.

Each region had differing local contexts, resulting in differing responsibilities and roles of stakeholders in the project implementation. The regional project leader named the potential interview partners and helped in organizing the interviews.

The **bus drivers** interviewed in the pre-test phase knew or assumed that they would drive the hydrogen bus. The post-test interviews only included bus drivers who were participating in the regional hydrogen bus project(s) and had driven the buses. The bus drivers interviewed were identified by the regional bus operators who also supported the organization of the interviews.

The **interviews of the general public (citizens)** were confined to the post-test phase only in order to reduce research expenditure. It was assumed that due to the usually low share of hydrogen buses in the local fleets, the group of citizens interviewed would comprise people with and without hydrogen bus experiences. This assumption was confirmed in the interviews. The post-test interviews allowed for evaluation of the spontaneous feedback (hydrogen buses and hydrogen infrastructure) from the general public in all of the research regions except for one. In this region the buses and the infrastructure hadn't been implemented at the time of the interviews due to time lags in procurement.

The **recruitment of citizens** for interview was a random selection after some basic characteristics had been satisfied. These were:

- all interviewees were using public transport and had used buses on a regular or occasional basis within the past 6 months,
- they either lived or worked on one of the hydrogen bus lines,
- the sample of interviewees selected aimed for an even distribution of socio-demographic characteristics, with respect to age (18-70 years), sex, education, residence (inner city, outskirts), and language[12]

The recruiting was done by specialized recruiting offices/ market research institutes situated in or nearby the regions being researched. The interviews took place in locations provided by the local project partners and were conducted by employees of the CHIC partner Spilett, the task leader responsible for the social research in WP 3.5.

12 Only in Bolzano/ South Tirol (Italian, German)

The **interview guidelines** used for all interviews were similarly structured for all interview groups:

Step 1 – Personal background and regional public transport context

Status quo, developments and perspectives, structural challenges of regional public transport with special focus on buses, user experiences and work environment

Step 2 – Individual (personal) expectations and experiences

of hydrogen and FCH technologies and with the hydrogen projects/ CHIC project

Step 3 – Strengths and weaknesses, opportunities and risks

Evaluation (self and as a representative of other local groups and interests) of expected or experienced attitudes (positive and negative), societal values and beliefs in the context of alternative drives and hydrogen technology use in transport.

The interviewees were invited to start with their own associations and thoughts on the topics addressed in the interview guidelines (see Table 4). Then, a structured interview approach was used in order to identify and deepen the researchers' understanding of the specific criteria and issues influencing the acceptance process. For each group of interviewees (citizens, bus drivers or selected stakeholders), the first two steps in particular differed in length and content, depending on the individual interviewee's priority of topics.

The interviews with bus drivers and citizens were complemented by an image analysis, consisting of a **list of project partners and statement cards**, forcing the interviewee to choose one out of two contrary positions and provide information and arguments as to why this option was chosen (Table 5).

Table 4: Overview of CHIC-interview guidelines

Introduction	+ Thanks for participating in the interview + Introduction to the interview (project background, study background, confidentiality, introduction to the interviewers) + Permission to record the interview (.mp3)
Personal background of the interviewee...	
...and working environment (bus drivers and service technicians)	+ Self-introduction of the interviewee + Motivation for work + Responsibilities and duties + Expectations / experiences
... and role in CHIC (project partners and regional decision makers / politics)	+ Self-introduction of the interviewee + Status quo of the regional bus services + Challenges of the public transport in the regional context
... and values (citizens / general public)	+ Self-introduction of the interviewee + Mobility patterns/ public transport + Societal challenges, awareness + Participation aspects + Use of innovations in daily life + Image of society
The CHIC project: organizational perspective of ...	
... bus drivers and service technicians	+ Project specific additional responsibilities and duties + History of participation in the project + Expectations of bus performance and handling + Experiences with the technology + General experiences with the implementation of innovations + Information level on the project (before and during implementation)
... project partners and regional decision makers / politics	+ Organizational and personal role in the CHIC project + Regional importance and institutional acceptance of the CHIC project + Project implementation in the region + Planned / implemented construction work with possible impacts beyond the project + Planned / implemented supporting activities + Planned / implemented training activities + Introduction of the hydrogen buses + History of the CHIC project and regional motivation patterns + Satisfaction with the CHIC project

... citizens / general public	+ Expectations of bus performance and infrastructure + Experiences with the technology + Image analysis of the hydrogen buses and the project partners + Project implementation / communication
The CHIC project: regional perspective	
	+ Potential winners and opponents to the introduction of hydrogen buses and the CHIC project + Image analysis of the hydrogen buses + Regional opinion formers + Supporters / opponents + Potential winners and opponents to the introduction of hydrogen buses and the CHIC project + Regional experiences with opponents + Expected / experienced impacts to the region + (Potential) winners and opponents to the introduction of hydrogen buses and the CHIC project + Preconditions for project and technology acceptance
Final questions	+ Topics not addressed in the interview/ questions + Encouragement to re-contact interviewee after introduction of the buses/ later in the project

Table 5: Interview material: Image analysis

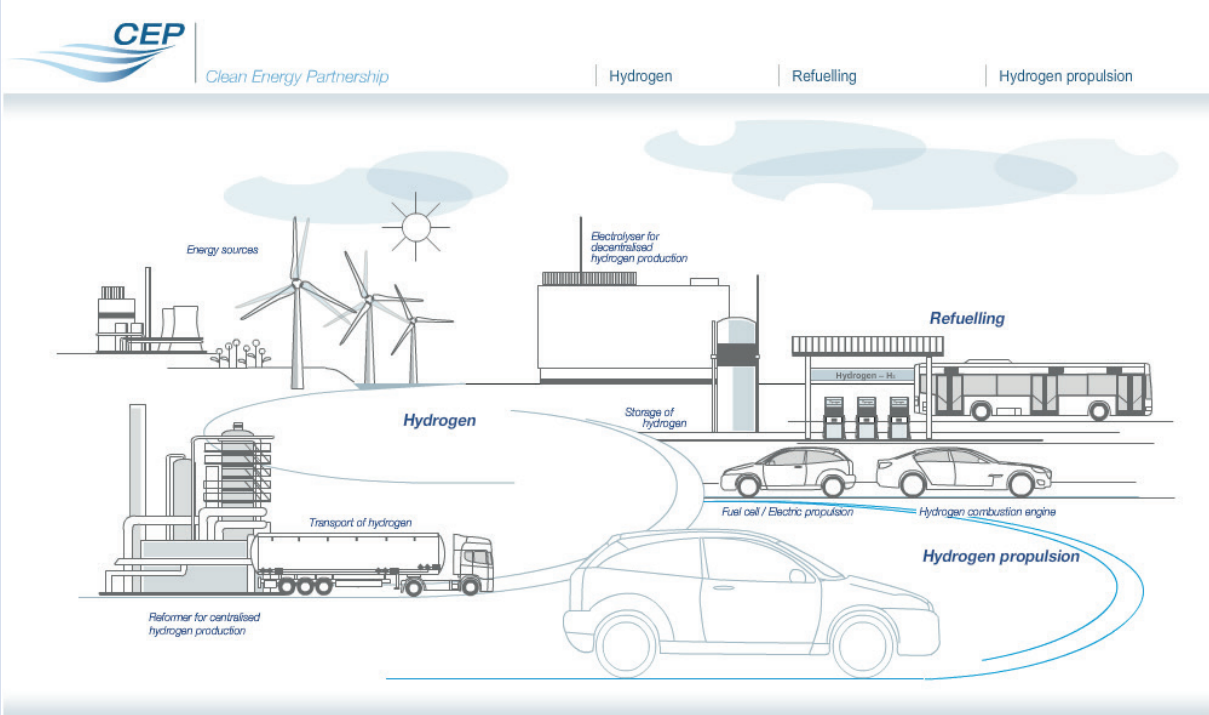
1 Technological solutions (hydrogen power trains) are an important step towards decarbonizing transport	↔	Changes in individual and societal behavior are path breaking in decarbonizing transport
2 Public transport bears fundamental societal responsibility for a climate saving mobility.	↔	Not public institutions but each individual is responsible to reduce the carbon footprint of mobility
3 Many people won't notice sitting in a hydrogen bus or a hydrogen bus passing by.	↔	Many people will notice sitting in a hydrogen bus or a hydrogen bus passing by.
4 The operation of hydrogen buses will be more expensive than this of buses with conventional drives.	↔	The operation of hydrogen buses will be cost-neutral or cheaper than this of buses with conventional drives.
5 The use of hydrogen buses will provide important impulses to the regional development (for example Economic growth, tourism, quality of life, regional identity...)	↔	The use of hydrogen buses won't have any implications to the regional development.
6 The use of hydrogen buses in public transport will result in an increase in demand for this alternative drives for passenger cars.	↔	The experiences with hydrogen buses won't change the public perspective on individual mobility, e.g. won't influence consumer choices when buying a passenger car.

The **show material** used in the citizens' interviews comprised a list of participating partners, pictures of the buses and the hydrogen station, and a map indicating the location of the station in order to verify the objects of discussion. The motivation to include show material was to

- verify that the interviewee and interviewer were discussing on the same topic
- evoke memories of where the bus or the station was seen (if interviewees didn't spontaneously remember)
- give interviewee an understanding of the buses and the station

The show material also included a graphic on the general technology concept (see Table 6), that was provided by the German Clean Energy Project (http://www.cleanenergyproject.de). It was known from previous projects, that the general public's awareness and knowledge about hydrogen technology concepts was likely to be very low. Introducing the technology concept was intended to enable a useful discussion and evaluation of the idea behind the CHIC project and the regional activities on hydrogen. One of the interview regions used by-product hydrogen from a nearby chemical plant instead of renewable electricity. This difference was shown to the local citizens to be consistent with the regional system boundaries and allow for a comparative evaluation of the concepts.

Table 6: Interview material: Technology concept[13]



The interviews were digitally recorded (.mp3-files) in order to focus on interview discussion and have the opportunity to listen to some of the arguments put forward in the evaluation phase. All interviewees were guaranteed strict confidentiality.

The **evaluation of the interviews** took as its basis the CHIC research theory. The statements in the interviews were grouped according to the research theories and compared within the region (all stakeholders), within the stakeholder groups (all regions) and

13 Clean Energy Partnership: Technology concept, 2012 (http://www.cleanenergypartnership.de/tech/site.php?l=en)

over time (pre- and post-tests). The evaluation identified new categories to be considered in the analysis (objects of acceptance, influencing factors). Results from all three levels of analysis were integrated into single reports for citizens, bus drivers and project environment (see Chapter 4-6). The consolidated findings are presented and discussed in Chapter 7 and the relevance to the implementation processes of hydrogen energy and FCH technologies into public transport identified.

4. "It is great – when it runs...!" – Analysis of the **bus drivers'** acceptance

4.1. Who are the people driving the buses?

The bus drivers involved in the day-to-day hydrogen bus operations have been either applied to become a "hydrogen bus driver" or were assigned to drive the buses due to organizational reasons (the size of the bus depot, the need to undertake a "hydrogen ambassador role" with the public, or the view that the buses have to be dispatched and used similarly to any other bus). All bus drivers who were chosen or assigned to drive the buses and participate in the project were qualified to drive and refuel the hydrogen buses. Looking at the results of the acceptance analysis it has to be kept in mind that these bus drivers might not reflect a representative opinion or attitudes of the complete group of (potential) bus drivers, as the selection criteria had (in most cases) already identified motivated and qualified people. Having noted this, the interviews also included feedback the bus drivers received from their colleagues, so some first conclusions on how the technology might be accepted in a broad-scale implementation including all bus drivers can be drawn.

The **group of bus drivers** interviewed for the CHIC social research on acceptance can be characterised as follows:

- Almost all bus drivers had **worked in their job for many years**, with the median length of time being 10 years with a range of 1 year to 38 years.
- Most of the bus drivers had **worked in another field** before they became bus drivers. Only a few had been bus drivers from the beginning of their career. The working background was diverse: *truck drivers, mechanics/ technicians (electricians, motorcar mechanics, auto dentists), and people with experience in project management, leadership and training of employees.*
- Some of the bus drivers were also **responsible for other activities**, e.g. cleaning the buses, dispatching (organising bus and driver schedules) and service and maintenance of the buses.
- The **reasons for becoming a bus driver** were individual and included most particularly

- *unsatisfactory economic situation*, including unemployment/ temporary work
- *additional income and self-fulfilment* for senior citizens
- *health impacts* of former work environment (illness, stress, age-related issues)
- *family commitments* (long absence from home was not accepted anymore)
- *desire to drive buses* (technical aspects, size of vehicle)
- *working with people* (social context of bus driving)

The interviewed bus drivers showed a detailed and up-to-date knowledge of bus technologies as well as a profound understanding of passenger needs.

Most of the bus drivers interviewed seemed to like their job and despite the different motivations for becoming a bus driver **they share two characteristics: an interest in bus technologies as well as in the passenger service**. These shared motivations are important for the understanding of the acceptance process among bus drivers. The personal and work experience of the bus drivers also indicate that they are experts in evaluating bus technologies, passenger needs and their work environment. They not only have practical experience but also an understanding of the technology and of bus performance due to their technical qualification and/or personal interest. A significant number of the bus drivers showed a detailed and up-to-date knowledge of bus technologies.

"Everybody notices what we are doing..." – driving buses is a very public work environment

It is important to understand that the bus drivers interviewed were well aware of their central position at the interface of public transport (and therefore the hydrogen bus project) and the general public: *"Everybody notices what we are doing..."* – the very public working situation of bus drivers explained their keen desire to perform well and be prepared for every situation. They reported feeling embarrassed if they couldn't answer questions or had to tell people the expected quality of service could not be provided, even if they were not responsible or to be blamed for the situation.

The sample of bus drivers interviewed in the CHIC research consisted of approximately 50% regular and 50% occasional hydrogen bus drivers. The assignments to the hydrogen buses depended upon the shifts, the lines and the ratio of bus drivers to hydrogen buses. Therefore not all bus drivers in the sample had comparable amounts of experience with the buses and the filling stations.

4.2. Acceptance levels among bus drivers at the times of interviews

The acceptance level of FCH buses and hydrogen infrastructure among bus drivers at the times of interviews in the five regions under investigation can be summarized as being emotional and increasingly extreme with time:

+ **enthusiastic** as long as the technology worked and
+ **frustrated** when it failed.

It was especially the electric drive and the energy management that seemed to be responsible for both the extremes. The acceptance level seemed to be strongly influenced by the time of interviews.

The high motivation of the bus drivers interviewed and positive experiences with the electric drive system resulted in a very high "willingness-to-accept", making up for some frustrations over technology performance. This attitude is not likely to be representative for all potential/ future bus drivers. At the same time, the very reflective and differentiated feedback on the technology concept and the bus performance that was presented in the interviews also indicates, that the bus drivers selected for the interviews (or the project) do react more sensitively to technological performance in either direction: to the advantages as well as to the disadvantages.

4.2.1. Initial situation

It was expected that the bus drivers who voluntarily applied for participation in the project started with a *supportive (positive) acceptance level,* whereas bus drivers who were assigned to the project were of *unknown initial acceptance*.

Motivations to participate in the project included

+ curiosity about the technology concept and its performance
+ making a difference ("ambassador" for a good idea)
+ diversification of work scope
+ valorization of vita

Some of the interviewees noted that there were colleagues who were not interested in applying for participation or who stopped their participation. Others reported on that there was some envy and discontent among those who weren't given the opportunity to drive the buses.

Reasons for deciding against participation included

- **technology characteristics:** expected low reliability of the buses, safety concerns, lack of interest in hydrogen technologies
- **project characteristics:** unpopular bus lines, unpopular time schedules (lower payments due to reduced amount of night shifts), additional work load (cleaning, refueling), application procedures and criteria

In regions that not only were demonstrating a new drive/ fuel system but simultaneously were testing a new bus concept (design, producer), the motivation to participate or stay in the project seemed to be reduced.

4.2.2. Pre-test situation

The pre-test interviews were conducted before the arrival of the buses and during the development of the hydrogen stations. They reflect the bus drivers' expectations of the technology (concept, characteristics and performance) and the project implementation. Although results in the pre-test phase are less precise than in the post-test phase (experiences and feedback), a differentiated picture can be drawn of the acceptance levels over all regions at the time of interviews:

Table 7: Acceptance levels of the bus drivers (pre-tests), n=15

Object of acceptance	Level	Description of acceptance
The project initiative demonstrating hydrogen technologies in public transport	++	Regarded with favour, acknowledged that "somebody is (finally) taking action"
Hydrogen as an alternative fuel	+	Some question environmental benefit and address origin of hydrogen, no general critics or refusal of the use of hydrogen as a fuel
FCH buses to be operated in the regions	o	Expectations about performance dominated the interviews (sceptical views on reliability and power capacities), a few bus drivers expected comparable performance and characteristics to conventional buses
Safety	+	Safety issues of hydrogen and hydrogen technologies were addressed by the interviewees but were considered to be not relevant or alarming.

++ = supporting + = agreeing o = tolerating - = criticizing -- = refusing

Prior to the project implementation, many of the bus drivers were unaware of the potential added value of hydrogen buses to their daily work life.

It is noticeable that advantages of the use of hydrogen buses in public transport were hardly addressed except at a rather theoretical level in relation to environmental benefits. **Many of the bus drivers did not seem to have any idea of the potential added value that might come along with hydrogen buses in terms of their work environment and the situation for their passengers.**

The regional comparison of the pre-test interviews with the bus drivers revealed a possible impact on expectations of information events prior to bus operation: The technology was evaluated more critically in regions where bus drivers had been trained or offered information events on hydrogen technologies and the project. Critical statements from the more informed bus drivers were more frequent in quantity and more detailed in quality. Two possible explanations for this phenomenon could be:

- The higher information levels lead to a better understanding of the technology and thus of potentially critical issues. The information exchange between colleagues resulting from training or information events might also foster the exchange of criticisms of the technology.
- The project partner responsible for the training– intentionally or not – managed expectations and “undersold” the project to avoid disappointment in the project (and thus included negative aspects in the discussion).

4.2.3. Post-test situation

Experiences with the technology and the project resulted in more accentuated evaluation of both positive and negative aspects.

The acceptance at the time of the post-test interviews was more precisely articulated by bus drivers than at the time of the pre-test interviews. Experience with the technology in particular and the project in general resulted in a significant broadening of topics that were addressed and a more accentuated evaluation of both positive and negative aspects. The changes are presented in Table 8.

Table 8: Comparison of bus drivers' acceptance levels (pre- and post-tests), n=37

	Pre-test		Post-test	
Object of acceptance	**Level**	**Description of acceptance**	**Level**	**Description of acceptance**
The project initiative demonstrating hydrogen technologies in public transport	++	Regarded with favour, acknowledged that "somebody is (finally) taking action"	++	The support of the project initiative remained unchanged and was high. The potential environmental benefit accounts for this strong support.
			+/ -	The implementation process of the hydrogen buses and the station was evaluated diversely, due to the different characteristics of the project implementation in each region.
Hydrogen as an alternative fuel	+	Some question environmental benefit and address origin of hydrogen, no general critics or refusal of the use of hydrogen as a fuel	+	A minor group of bus drivers still questioned environmental benefits of hydrogen technologies.
FCH buses to be operated in the regions	o	Expectations about performance dominated the interviews (sceptical views on reliability and power capacities), a few bus drivers expected comparable performance and characteristics to conventional buses	++	The **driving comfort** of the FCH buses resulting from the electric drive train enthused both bus drivers and passengers (as reported by the bus drivers). The driving comfort and the resulting effects on the work environment dominated the interviews and overshadows some of the negative experiences related.
			+/-	**Technical problems and reliability** of the buses influenced acceptance. The degree to which acceptance was reduced by these issues depended on the processes and framing of the problem solving (times, information and level of progress)

FCH buses to be operated in the regions			+/ -	The **technology potential of hydrogen buses** produced divergent responses: from "already suitable for daily use" and "progressing" to "shows potential" and "no real alternative for today" (mainly due to cost and reliability)
			+/ -	In regions where they not only changed the drive train/ fuel concepts but also altered the **characteristics of the work environment** (design of the bus and the work place), bus drivers reacted as much to these changes as to the changes in the drive train/ fuel system. Acceptance also decreased due to non-hydrogen related issues as e.g. time needed to close the doors, navigation support systems for the bus drivers, and design of the entrance. It also increased due to e.g. the design of the bus, and changes in operation (fewer nightshifts, easy lines).
Safety	+	Safety issues of hydrogen and hydrogen technologies were addressed by the interviewees but were considered to be not relevant or alarming.	+	Safety issues were evaluated as in the pre-test interviews. Safety of hydrogen technologies was seen non-critical and comparable to the risks of alternative/ conventional technologies. The safety discussion was broadened to include the hydrogen station, which was not addressed in the pre-test.

++ = supporting + = agreeing o = tolerating - = criticizing -- = refusing

4.3. Influencing factors in the acceptance process

The results of the interviews confirm the research theory that acceptance has to be understood as a dynamic process, influenced by a large range of factors. The pre- and post-test interviews revealed some of the influencing factors in the acceptance process in the five CHIC-regions chosen for the social research.

4.3.1. Regional context

The activities to demonstrate FCH technologies in public transport have always to be placed into an existing regional context – consisting of accepted structures, processes, responsibilities and political strategies. Additionally, each region implicitly or explicitly values changes to their context based on experience with previous/ other activities and people associated with the changes. The regional context should therefore be considered as "given" with only limited possibilities of being shaped and with strong influence on the design and success of the implementation processes of FCH technologies in public transport. The technology concepts as well as the implementation processes should therefore be aligned to the regional context rather than forced onto it. Where possible, preparation of the regional context prior to the project could be useful.

The influence of the regional context on the acceptance on the FCH bus project in the five regions investigated in the CHIC research can be categorized into

Challenges to the regional public transport services: growing demand. Many of the interview regions faced a growing demand for public transport either due to a growing population or due to limited road capacities. This has resulted in crowded buses, a lack of seats or a reduced service if money has to be used for more urgent matters. The bus drivers had noticed an increasing stress among the passengers and unwillingness to accept temporary disruptions. As the bus drivers were the interface with the customer, they experienced very direct feedback every day. The consistent availability of buses in the fleet was considered increasingly important in order to avoid stressful situations. Therefore reliability and length of service times (maintenance and repair) directly influenced acceptance of the technology in use.

Many of the interview regions faced a growing demand for public transport. As a result, the bus drivers had noticed an increasing stress among the passengers and unwillingness to accept temporary disruptions.

Keeping up with schedules is a central challenge to bus operation. Every change to the "running system" risks severe troubles to the overall system performance.

Challenges to the bus operators: time pressure. Four out of the five interview regions were experiencing increasing **time pressure** on the bus drivers to keep up with the schedules and be on time (in order to make connections, to achieve quality goals and to secure passenger satisfaction). *"From the bus to the driver – the complete system has to work properly"* summarized one bus driver, indicating that every change to the "running system" risked severe troubles to the overall system performance. Demonstrating a new technology in this context resulted in additional stress and consequently reduced acceptance as long as reliability was not at 100% or buses had to be exchanged on the line.

The main factors increasing time pressure were more passengers (increasing time needed at each stop), increased road traffic and traffic congestion due to road works, more stops on the lines and tight connection schedules. Short buffer times at the end of each line aggravated the situation and did not allow for catching up lag time.

Experiences with innovations in public transport: The bus drivers in several regions reported on the introduction of a new ticket system, resulting in an additional work load for the bus drivers, as they then had to sell tickets, and provide information on tariffs and connections. Some of the bus drivers were unsettled by the new system, and many bus drivers reported disconcerted passengers.

As with time pressure, changes in work load might have influenced the motivation and patience of some bus drivers to concurrently test technology innovations.

Experiences with alternative drives and fuels: Many of the bus drivers had had prior experiences with alternative drives or fuels. Previous negative experiences risked decreasing acceptance of the FCH buses in the pre-test phase as technology performance was assumed to be similar with the new buses (scepticism). It was explicitly stated that a better performance was expected (hoped for) in regard to

- power management (experience: slow acceleration, insufficient acceleration to reach speed before the next stop)
- gear drive (experience: "bumpiness", resulting in passenger remarks on bus drivers' competence)
- reliability

Level of information on hydrogen technologies: None of the bus drivers interviewed in the phase 1 regions had had prior hands-on experience with hydrogen buses. Some of the bus drivers had seen the buses in pictures or videos in a project related information event, others proactively searched for information on the internet. It seemed to be not only the depth of information but also the kind of information that influenced acceptance levels of the bus drivers.

In regions where bus drivers were simply assigned to drive the buses, expectations positively influenced acceptance (surprised by the technology). Bus drivers who had actively applied for participation seemed to be more disappointed. The need for a balance of "overselling" to attract people versus "underselling" to avoid disappointments and decreasing acceptance was well illustrated in this group of interviewees.

4.3.2. Technology concept: Hydrogen as a fuel

At the time of the interviews, the bus drivers estimated the technology potential of hydrogen as promising, provided that technology performance would improve over time and challenges were overcome.

The **potential environmental benefit** seemed to be particularly convincing, as the reduction of both the local emissions and climate emissions was mentioned several times in the interviews. On the other hand, the environmental benefits were questioned by some of the bus drivers pointing at the origins of the hydrogen and electricity. One of these sceptical bus drivers questioned the whole initiative in the event that hydrogen would not be produced in a carbon neutral fashion.

Hydrogen was seen as being a promising technological solution from today's perspective, without being the sole energy technology solution.

The positive connotation of the initiative also included additional aspects of **security of energy supply**: oil based fuels were seen as old-fashioned whereas hydrogen was perceived as a fuel of the future. Hydrogen was seen as being a promising technological solution from today's perspective, without being the sole energy technology solution. Other technology concepts should be followed and developed too.

The interviewees **expected hydrogen technologies to be more expensive** than conventional technologies or alternatives. Arguments were mainly of a general kind *("new technologies are always more expensive", "risk of innovation", "development cost")* and not explicitly linked to hydrogen technologies. Although the bus drivers did not evaluate the size of cost, they assumed the cost

of hydrogen technologies would have to decline in order to be accepted by the market. One of the bus drivers stated that *"it was a good feeling not to be responsible for paying the refueling bill".*

Stating "no safety concerns" does not imply "no risk consciousness", as people place trust in the responsible actors.

The **safety discussion** revealed an important (implicit) premise of the bus drivers that was also identified in other interviews among in the general public and selected stakeholders: Stating "no safety concerns" does not imply "no risk consciousness", as people place trust in the responsible actors. They relied on "the system" that would not approve anything harmful to health or life, and took care that even misuse would not result in any severe damage. They also implicitly assumed that any innovation was at least as safe as its existing alternative. This high level of trust in authorities might explain the differences of safety discussions on hydrogen technologies in this research compared to countries outside Europe; it might also explain the evident low interest in discussing safety issues

It nevertheless was reported by some bus drivers, that colleagues had addressed safety concerns in the past. The fact that bus drivers addressed safety issues spontaneously in the interviews indicated a certain level of awareness and a general interest.

4.3.3. Technology characteristics: FCH buses

The electric drive of the FCH bus appealed the most, and significantly increased acceptance in the group of bus drivers.

It can be clearly stated that it is the **electric drive** of the FCH bus that appealed the most, and significantly increased acceptance. The bus drivers had already expected and described some of the characteristics of electric driving in the pre-test interviews but noted them without much emotion. In the post-test interviews, the discussion on the electric drives was full of emotion: the descriptions became more colorful and precise, and the value added to the bus drivers' work environment and to the passengers' experience was spontaneously discussed.

In particular, the following added values produced great enthusiasm:

+ The smooth driving **reduced health impacts** on the bus drivers. They reported fewer headaches and back pain as well as a more relaxed humor even after long working days. They evaluated the drive as a significant improvement to the work environment of bus drivers. One bus driver even recommended: *"If you are looking for a good car, take a hydrogen one!"*

- The added value for the passengers was considered to be due to the smooth driving (allowing for reading books and newspapers) and the possibility of **standing and walking in the bus even when the bus pulled out**. This especially assisted in mitigating the time pressure on the bus service, as one bus driver stated *"I gain time when I do not have to wait for the old lady to find a seat."*

- The passengers tended to attach the smooth driving to the bus driver's competence and gave **positive feedback**. This motivated and flattered the bus drivers, although not all immediately clarified their role in the context.

- The **quietness and lack of vibrations** of the idling engine justified the use of air conditioning and heating devices at the end of the lines, during "down time" for the bus drivers. Some of the interviewees explained that with diesel or biogas buses they were not allowed to run the engine in an idling position due to the possibility of annoying residents. They evaluated this difference in electric drive train buses as being an important improvement to their work environment and the neighborhood.

- The **traction power (torque)** allowed for a faster start of the buses even with a high passenger load, which surprised a substantial number of the bus drivers interviewed.

Technology characteristics resulting in time lags or effecting the safe driving of the buses reduced acceptance of the buses.

Some **disadvantages of the FCH buses** were also addressed and discussed in the interviews: A few bus drivers reported on an annoying sound inside the bus while driving (whistling). According to them, even some of the passengers reacted to the sound (especially children). One bus driver believed that the sound caught his attention as he expected the bus to be completely silent. High costs also were mentioned several times as a possible reason for a lack of market acceptance in the long run. In the short term, higher costs were seen as normal and justified due to the innovatory nature of the technology. Sporadic criticisms related to the range of the buses (too small) and the battery power management in the mountains (long periods of ascending slope). The expectation in the pre-test interviews that the silent driving of the buses might be a risk to pedestrians was not mentioned at all in the post-test interviews.

As the buses differed not only in the drive train from other buses in the fleet, many **aspects of non-hydrogen or non-drive train related issues** were addressed in almost all regions. A positive impact on acceptance was the visibility of the buses to people on the streets and the passengers. It seemed that hydrogen buses were not only visible by their color or outside labeling but

also differentiated in size or profile, which led to more reactions reported by the bus drivers. They commented on people raising thumbs when passing by or passengers asking for the buses with the tail pipe on the top. As the majority of reactions were positive, bus drivers felt proud and motivated by these reactions.

Bus drivers felt disregarded when drive train / hydrogen system related problems seemed to have a higher priority to be solved than issues directly impacting the quality of their work situation.

The **criticisms** focused on three categories: implications of the new technology on the work environment, on driver-passenger relations and implications for driving routines. The very individual nature of feedback resulted from the differing regional characteristics of the technology introduced and the project implementation (e.g. prior-experience with the bus type, intensity of local supplier support etc.). Due to confidentiality reasons these regional differences will not be discussed in detail in this report.

In aggregated summary, it can be said that technology characteristics resulting in time lags or effecting the safe driving of the buses reduced acceptance of the buses, e.g. time needed to close doors, and unsatisfying software to control backing of the bus. Bus drivers referred to their personal responsibility and liability and **felt disregarded** when drive train / hydrogen system related problems seemed to have a higher priority to be solved than issues directly impacting the quality of their work situation *("only details for them", "not the BIG hydrogen questions")*. Some of the interviewees were anxiously anticipating the day when the bus had to by-pass a stop due to exceeding hub load, leaving passengers in the rain although the bus seemed to still have additional capacity (i.e. free standing room inside the bus).

Fuel consumption and energy management was hardly mentioned in the interviews. Only two bus drivers reported on trials to optimize recuperation and fuel consumption by altering driving and breaking behavior (and watching the displays). Most of the bus drivers did not address fuel consumption of the hybrid buses at all. This may have resulted from the fact that a comparison of conventional fuel consumption (diesel and gasoline, measured in litres) and hydrogen consumption (measured in kg) was not easy and required a calculation. It might also indicate that the time pressure many of the bus drivers described in the interviews did not allow for "experimenting on the line services".

Compared to other drive trains and fuels, the bus drivers evaluated the characteristics, performance and potential of FCH buses as shown in Table 9.

Table 9: Acceptance levels of FCH buses compared to alternatives, n=37

	FCH bus	Trolley bus	Serial diesel hybrid bus	Diesel ICE	Biogas ICE
emission free (local air quality)	●	not discussed	not discussed	●	●
climate neutral	●	not discussed	●	●	●
smooth driving	●	●	●	●	●
soundscape	●	●	not discussed	●	not discussed
passenger capacities	●	not discussed	not discussed	●	not discussed
reliability	●	not discussed	not discussed	●	not discussed
cost	●	not discussed	not discussed	●	●

● significantly better
● better
● comparable, tendency better
● significantly worse
● worse
● comparable, tendency worse

Most of the interviewees were used to or had had experience with driving different bus technologies prior to the introduction of FCH buses. In particular diesel hybrids and biogas buses were named as alternative drives. Only a few bus drivers had prior experience with driving trolley buses, more had experienced trolley buses as a passenger. The **advantages of FCH buses** compared to trolley buses and diesel hybrids (all sharing the advantages of the electric drive) were stated as being the flexibility of lines (compared to trolley buses) and the possible independence from fossil fuels (compared to diesel hybrids). Advantages of FCH buses compared to carbon neutral biogas buses were seen as smooth driving and improving local air quality. In some regions, the handling of biogas buses was experienced as being “bumpy” and uncomfortable for the bus drivers and the passengers, resulting in a low acceptance of this technology. The interviewees commented on their surprise when first driving the FCH buses, as their expectation of “environmentally friendly” technologies had been low.

According to the majority of interviewees, any current bus driver would be able to drive a FCH bus.

One of the interview regions had prior experiences with hydrogen in public transport, so the interviewees could compare the technology characteristics of **two bus generations** from the same bus supplier. They discussed positive and negative aspects focusing on improvements that were identified with the new generation. These included

- an increase in smooth driving (even noticeable to the passenger)
- a decrease in noise level
- less top-heaviness and a reduced vehicle weight
- a lowered vehicle size resulting in a higher operational flexibility
- an increased passenger capacity
- a better range
- a faster refueling process

Adjusting driving behavior to the FCH bus technology was seen as being uncomplicated, even changing buses within a shift did not cause any problem. Completely new bus designs and concepts may nevertheless be challenging to the bus drivers and requiring some (more) time to adjust. Some of the adjustments resulting from the design of the buses or the drive train/ energy management system included

- more time needed to switch on/ off the bus
- a higher centre of gravity (top-heaviness) resulting in different cornering ability.

Besides personal experience with the technology, acceptance seemed to be influenced by the feedback the bus drivers got from passengers and in their personal life.

Some bus drivers seemed to be disappointed by the lack of attention and feedback, especially if the motivation to participate in the project had been "making a difference" (ambassador of the technology).

The reactions from passengers to the FCH bus characteristics were significantly lower than expected by most of the bus drivers. Some bus drivers seemed to be disappointed by the lack of attention and feedback, especially if the motivation to participate in the project had been "making a difference" (ambassador of the technology). Most of the bus drivers stated that passengers' feedback was predominantly positive, with a focus on the smooth ride. The reduced noise level also attracted attention, which was either addressed directly to the bus drivers or could be indirectly noticed by e.g. declining volumes of mobile (telephone) conversations in the bus. Passengers mainly asked questions on the local environmental benefits (water vapor emissions). Only a few passengers asked for more information on the technology (concept and functionality). The reason for this might be twofold – they either didn't expect the bus driver to be able to answer their questions, or they simply were not interested. In several regions, information on the buses and the project had been provided on the bus.

Negative reactions to the technology characteristics were only sporadic and related to safety concerns, indoor sounds/ whistling, costs and reduced passenger capacities of the buses. In particular the passenger capacity was mentioned and a cause for concern to some of the bus drivers. They feared that due to vehicle weight, the passenger capacity of the buses might be overestimated by the passengers. In their opinion, passengers waiting at the stops in rush-hour times would not always understand why a bus with apparently remaining capacity could not load more passengers.

The **overall interest of the passengers and the citizens was reported as declining over time;** some bus drivers noticed and reported on significantly more passengers and people stopping on the roads and taking pictures of the bus or taking a ride at the beginning of the project.

The **passengers who gave feedback** on the buses could not be categorized to any specific demographic or social characteristics. Only children and pupils seemed to be significantly more interested in the buses than others. It was reported that they on the one hand seem to better notice differences in the buses (color and design), on the other hand they were likely to address questions more frankly to the bus drivers and their companions.

In one region, children used the bus rides as an event, enjoying the swivel out of the rear end of the bus.

The reactions from families and friends to the drivers' participation in the project might also be an important influencing factor in motivation and resulting acceptance by the bus drivers. Reactions that were reported by the bus drivers can be summarized into three categories:

- **Frequent and supportive:** Bus drivers who had deliberately (and proudly) communicated the project to their family and friends received positive feedback; children and grand-children seemed to initiate talks on the project and the technology more frequently than adults who mainly (only) reacted to TV spots or news articles.

- **Occasional and neutral:** Bus drivers who seemed to report less frequently on the project and the technology in their private life, did not notice any significant additional or lasting interest. It wasn't possible to evaluate if there was a causal relationship between bus drivers' behavior and reactions, i.e. if the lack of peer group interest led to the reduced will of the bus drivers to communicate or vice versa.

- **No reactions at all:** Some of the interviewees stated that they avoid mixing private life and work, and consequently hadn't informed people in their private life of their participation in the project at all. They assumed that nobody would be interested in hydrogen projects anyway.

4.3.4. Technology performance: FCH buses

A main concern in the pre-test interviews was the **reliability of the buses**. One bus driver summarized expectation as being *"A good idea that has to prove itself".* The expectations about reliability resulted from either former experience with alternative drives and fuels (e.g. biogas buses) or the fact that the innovation process was not yet completed in FCH buses. They believed in the reason for reduced reliability would be inevitable teething problems with the technology.

The majority of the bus drivers in all regions had expected the buses to be "experimental", so they were not too greatly surprised that the buses were not 100% reliable, and still had to be optimized during the project.

The post-test interviews focussing on actual experience revealed technical problems especially at the beginning of the bus demonstration. Numerous failure messages and outages of the buses were reported by the bus drivers and decreased the acceptance of some of the bus drivers (*"tired of the project"*). Other bus drivers unemotionally reported on failures and outages, and their acceptance levels seemed unaffected. The majority of the bus drivers in all regions had expected the buses to be "experimental", so they were not too greatly surprised that the buses were not 100% reliable, and still had to be optimized during the project. The actual reliability experienced at the times of the post-test interviews was seen as being acceptable for a test project but not suitable for daily use, especially if scaling up to be a higher share of the bus fleet was envisaged.

The **framing of the project as a trial as well as organisational backing** were important activities to stabilize acceptance. This included

- dispatching reserves (buses and drivers) to make up for failures on the road or outages due to maintenance and repair activities,
- operating the buses on lines and at times with uncritical passenger loads (outside rush-hours)

The framing of the project as a trial turned out to be an important factor to stabilize acceptance.

Without this support, acceptance among bus drivers might have decreased significantly. One reason leading to this conclusion is that *"providing a good service to the passengers"* was of utmost importance to the bus drivers – and the regional project partners were successful in securing this goal, as can be seen in the chapter analysing the passengers' views.

The **increasing familiarity** with the FCH buses over time as well as information provided by the suppliers on how to cope with failure messages also resulted in a stabilization of acceptance. Bus drivers became more confident in how to interpret failure messages and could resolve some of the issues themselves. Many of the failure messages which did not explicitly require an immediate reaction from the bus drivers were suppressed by the bus suppliers.

As a result of the bus reliability experienced some of the interviewees **suggested extending the test drive phase** of the buses in order to stabilize the technology system before operating them under real-life conditions, risking the passenger acceptance due to unreliability or increasing the work load and stress of operators and bus drivers charged with securing services and explaining delays. *Future projects should consider this when calculating time and effort.*

4.3.5. Technology characteristics and performance: Hydrogen filling stations

At the time of the interviews, issues to do with the hydrogen filling station were of secondary importance to the bus drivers. Only a little feedback was provided spontaneously, most of the discussions on the filling station had to be initiated by the interviewers. Discussions were less animated and detailed than with the buses. This might be due to fact that the bus drivers had started filling the buses on their own only a short time before the interview and therefore had used the station very little when compared with their experience with the buses. Another explanation could be that the interest in the station was simply less as it was not their main working environment.

Safety issues were a topic of interest for some of the bus drivers, safety concerns however were the exception. Initial questions on safety had been addressed in bus driver training. Additional reasons for the apparent lack of interest in safety issues are addressed in Chapter 4.3.2.

Using the hydrogen station was considered to be simple as long as refuelling procedures were followed and remembered. Initial concern or hesitance was reported by some of the interviewees, but would be overcome with a continuous use of the station. An on-going exchange on problems and solutions was established with colleagues to avoid repetition of problems and increased familiarity with the technology occurred for bus drivers who only occasionally filled the buses.

Besides differences in the filling procedures, the **filling time** was identified as one of the main differences between hydrogen stations and conventional refuellers. The bus drivers had noticed varying filling times between 5 and 30 minutes. As HRS stations were not located at the bus depot in all regions, additional time needed for bus fillings was integrated into the bus drivers' schedules. It was not the effective time needed to fill the buses that was relevant for the bus operation, but the need to stay with the buses during filling. Even if the filling station was situated at the depot, staying with the bus or placing the bus next to the filling station (instead of the workshop as with diesel buses) resulted in changes to procedures.

- It was reported that with **diesel buses**, filling used to be simultaneous with other required activities e.g. cleaning the buses (in the workshop). Filling time in this case was zero, as it allowed for these activities.

- Other bus drivers mentioned **biogas** buses being plugged in at the gas station after the last shift and left for overnight filling.

An increase of FCH buses in the fleet would require adaptations of operational processes and filling procedures, as current activities require additional time efforts to service the buses.

At the time of the interviews, the regions had up to 5 buses in operation, therefore an individual **adaptation of operational processes** to accommodate the system needs of hydrogen buses and stations was not considered a significant disturbance. Nevertheless it has to be kept in mind that with an increasing share of hydrogen buses in the fleets, solutions to either change organizational processes or adapt technology systems to the operators' needs will become more and more important. Some of the interviewees stated that it would be mandatory to locate the hydrogen station on the bus depot.

The **reliability of the hydrogen stations** produced diverse and sometimes opposing comment: Some interviewees reported on a good reliability, others mentioned long periods of outage affecting the operation of the buses, both within the same region. Bus drivers experiencing a lower reliability of the stations demanded not only a reduction of the amount of failures/ problems but also a shortening of the time needed to bring the station back into operation. It was mentioned that potential suppliers of spare parts, located in the region, should be included in the projects.

Room for improvement was seen in aspects of the **user friendliness** of the stations:

- Ways to be covered several times during the filling process (e.g. between nozzle and display and card reader) annoyed some of the drivers, especially if the reasons for placing equipment or defining filling procedures were non-transparent or apparently not well defined.
- Bad readability of the screens and displays due to a lack of lighting or reflecting sunlight.
- Insufficient rain shields at the dispenser.

4.3.6. Project structures and processes

Decisions on project structures and processes (scheduling of the buses, responsibilities reporting needs, trainings, information flow, feedback etc.) influenced the acceptance process of the bus drivers as well as the technology itself. The decisions taken either supported changes in daily routines and work environment or resulted in an additional work load and increased uncertainty for bus drivers. Some of the structures and processes were common to all CHIC regions, as they were closely connected to the overall CHIC project. Others were based on decisions by regional and industry stakeholders, and differed between the regions reflecting context, project history and the interests within the project environment. Decisions on the regional project structures and processes were partly specifically designed, and partly a result of (unconscious) existing structures and relationships.

The implementation of hydrogen technologies in public transport changed work **routines** for the participating bus drivers in all of the interview regions. The workplace (bus) as well as the working situation of the bus drivers and the dispatchers had to be adapted. Based on the feedback received in the interviews these modifications seemed to not significantly influence the acceptance process.

The implementation of hydrogen technologies in public transport changed work routines for the participating bus drivers in all of the interview regions.

Additional duties, such as filling and cleaning the buses (some regions), and the change of bus lines did not discourage the participating bus drivers although it was mentioned that some bus drivers did not apply due to expected changes in work load and work environment. A possible explanation for the positive acceptance of additional duties could be that they were scheduled within the usual working hours, so they did not result in overtime being required. A few bus drivers even suggested that changes to the work routines were one reason to participate in the project, as it diversified daily work. Last but not least, many bus drivers had been **unaware of possible changes** in the pre-test interviews and thus at this point weren't disappointed, surprised or alienated.

When hydrogen bus operation led to an **improvement in the working** environment (e.g. reduced amount of night shifts, increasing operation on favored lines and enabling bus drivers to participate at special events or VIP rides) acceptance of the project and the technologies increased.

The overall relaxed attitude towards **planned, announced and foreseeable additional work** load might be a result of the relatively few hydrogen buses in the fleet. As soon as that share is increased, the working procedures will have to be readdressed as they will likely result very significant changes to routines and work load.

In the project, the dispatchers had to ensure bus service on the lines taking into account

- sequences of shifts when not all bus drivers were able/ allowed to drive hydrogen buses – the shifts then had to follow the additional requirement of providing continuous hydrogen bus service
- doubling up on buses that were not seen as being less reliable either with another hydrogen bus or a conventional bus and bus driver
- time needed to fill the buses and clean them – this additional work load reduced time available to provide services on the lines, buses and bus drivers had to be replaced when occupied with the hydrogen bus.

An expectation of the project that had been mentioned in the pre-test interviews was a dependable **organizational back up** in the case the buses did not perform reliably. This goal was reached by doubling buses, dispatching reserves (bus drivers and conventional buses), and aligning work schedules of bus drivers and technicians, so the passengers hardly noticed any inconvenience of the buses due to outages. So a significant and unexpected additional work load for bus drivers, dispatchers and service technicians resulted from a reduced reliability of the buses.

Extra work load resulting from **reporting on failure messages and filling data**, led to bus drivers wanting to reduce or limit extra work load beyond operating the buses on daily service. They queried for instance why performance data could not be logged and provided automatically.

Some bus drivers complained that they did not get the expected **feedback on failure reports and information**. They either experienced a recurrence of failure messages leading to the assumption that the problem had not been addressed by the suppliers, or they felt uninformed on the reasons for problems. They did not feel they were part of "the team", an important interface to identify potential for optimizing the technology for daily operation, but rather reported a "one-way-information" channel. Iin the words of one bus driver: *"We feed in information but do not get anything out."*

Remembering the motivation of many bus drivers to participate in the project was to "make a difference", the lack of appreciation of their commitment explains the decrease in motivation and project acceptance.

Remembering the motivation of many bus drivers to participate in the project was to "make a difference", the lack of appreciation of their commitment explains the decrease in motivation and project acceptance. Another risk resulting from not continuously requesting and including bus drivers' feedback is the decrease in motivation to proactively identify and communicate problems/ optimization potential, that might be out of scope of the technology partners, but important to the innovation process.

Most regions developed their **own feedback mechanisms** assigning key persons as interface with the technology suppliers. The information flow depended upon a single person, being an important facilitator and communicator. For the bus drivers, these key people were central and trusted individuals. The disadvantage of this informal mechanism was an increased responsibility to ensure information flow and a higher work load for the communicator, as well as a reduced information flow in times of that person's absence (illness, vacation etc.).

Bus drivers are the direct interface to the general public. Althought they feel sufficiently informed on the use of the technology, they lack information on the project progress and the regional and stakeholders motivation to engage.

Another motivation factor for bus driver participation, and in some regions a prerequisite for participation, was the anticipated role of an "ambassador of hydrogen technologies". Bus drivers are the direct **interface to the general public**, presenting the technology to the passengers and getting direct feedback both positive and negative. The regional project partners provided information to the bus drivers in training sessions, either online or on-site. Some of the training was official and included all bus drivers; others were unofficial and with single bus drivers, occurring when technicians and project partners were at the bus depot for service or maintenance activities. Bus drivers reported that they profited most from face-to-face training and unofficial talks to the engineers and technicians. These bus drivers appeared more enthusiastic, as they got answers to their specific questions and provided feedback. The acceptance process was positively influenced by a personal relationship and frequent, need-based (informal) information exchange between bus drivers/ key person and technicians / suppliers.

The amount of information provided about the technology was estimated to be sufficient to be able to react to passenger requests, but could have been more detailed for the drivers' personal understanding. Information provided in official **training sessions** at the beginning of the projects addressed

- Technology characteristics and functionalities
- High voltage and safety
- Driving and filling procedures

The practical trainings was considered sufficient to be able to drive and refuel the buses. Some bus drivers would have liked the theoretical information to be more detailed in regard to the scientific background. Although not necessary for the daily operation of the buses, they believed this information would allow for a better understanding of the background and potential of the technology. Bus drivers felt that **insufficient information on the overall project was provided**, e.g.

- the motivation to implement the technology in the specific region,
- other regions participating in the project,
- technology progress and project partners/ environment,

- financing strategies,
- origin of hydrogen

They noted that it was the simple questions concerning the project context that passengers and colleagues asked about. They felt unable to reply to these kind of questions and wanted information to address this deficit. Some of the bus drivers researched answers to the questions on the internet or directly asked their project partners.

Information material and work sheets were positively evaluated when

- they referred to the contents of the trainings, summarizing practical information in an understandable fashion
- failure message templates were unambiguous, particularly in regard to quality and kind of requested information
- all information was provided in the national language to avoid people feeling excluded or information being misunderstood due to language barriers (failure protocols, training material, handbooks and failure displays)

It was the simple questions concerning the project context that passengers and colleagues asked about.

The supportive acceptance level of the bus drivers towards the project can be seen in the fact that in some regions they developed their own checklists and information sheets on procedures and characteristics of the buses, the filling process and the HRS station where these were lacking. They shared these documents with the other bus drivers at the depot. Although this initiative was valuable to the project and the authors of the documents had the best intentions, it risked misunderstandings and the circulation of wrong or incomplete information. Regular events to update information and discuss on these additional documents would be helpful to secure quality of information and understand the changing information needs of the bus drivers.

Some of the bus drivers felt the training sessions were too dense. The amount of information should be spread over several training sessions in order to avoid this. The advantage of a **training series** would allow for the hands on experience with the buses to lead to a better understanding of the information provided (providing a practical context instead of only theoretical backgrounds).

A training series would also allow for an improved feedback process and discussion of experiences with the project partners and the other bus drivers. Although the bus drivers suggested ideas to improve training and information materials, the quality of trainings did not significantly influence the acceptance process. Training material was seen as being "o.k." to "good", depending upon the regions and the individual trainers.

Participation at events and conferences as well as a personal relationship turned out to be a key factor to keep and increase acceptance.

A more critical factor to acceptance was identified as being **a lack of information exchange** in the implementation process. Most of the bus drivers were situated in their bus depots, only some of them shared information with other hydrogen bus drivers at the depot, and profited from each other's learning on technology operation and use. Bus drivers who were deployed for outside activities (local, regional or international events) seemed to be especially motivated. They gained insight into the hydrogen scene and existing activities/ strategies, and met regional and international stakeholders. The information provided at these external events comprised also the vision, which was seen as being important to better understand technology progress and project processes. **Participation at events and conferences (internal and external)** turned out to be a key factor to keep and increase acceptance, making up for (temporary) disappointments in regional projects.

Information exchange between bus drivers, either within one region or cross-regional or with other project partners and stakeholders was not originally set up in the project. Supporting project structures were still lacking at the time of the post-test interviews. Ignoring the bus drivers need for information and information exchange might result in resignation or refusal of the implementation process. It was explained to some of the bus drivers, that it was "unusual or not foreseen" to have them integrated into the information management loop, did not help acceptance levels but rather was perceived as an example of a deficit in project communication. The relevance of an inclusive information management loop was summarized by one interviewee as follows:

"As long as you depend upon the good will and the feedback of the bus drivers, you need to sell the project to them. One part of it is information management to keep people updated and secure a project image."

4.4. Preliminary conclusions

„ They are great, when they run!" - „Improving the work environment, if available..." - "Enthuses despite teething problems!"

The overall acceptance of the project initiative and the hydrogen technologies by the bus drivers can be summarized as being supportive to tolerating, but eroding. The driving comfort of the electric drive and the project idea convinced people and made up for set-backs in reliability and performance.

The bus drivers had supported the **project initiative** from the beginning; a key factor increasing acceptance was the intention to reduce the environmental impacts of transport. The acceptance of the initiative did not erode between the pre-and the post-test interviews and made up for some negative experiences and the high additional work load of the bus drivers.

The **FCH buses and the project implementation** processes were discussed more ambivalently, the experiences with the technology and the project aggravated this ambivalence: On the one hand smooth driving and a reduction of noise surprised and enthused the bus drivers and increased acceptance. On the other hand, non-hydrogen related problems, reliability and unsatisfactory **information flows** (feedback) and time to fix problems influenced the acceptance process. In particular "on-the-line" outages, failures and a lack of ability to respond to passengers' questions were perceived as **embarrassing situations** in a very public work environment, and significantly decreased acceptance.

It is obvious that low expectation levels (a critical view of the technology) prior to the start of the project did not automatically result in a low acceptance levels in the implementation phase – individual experiences and perceptions of the technologies and the implementation process are key to acceptance. Quite to the contrary, the analysis of the pre- and the post-test interviews in the different regions showed a higher acceptance level among bus drivers who had been informed and were skeptical. Both groups identified reliability and problems/ challenges similarly, but differed significantly in resulting attitudes: Project processes and impacts on the work environment were evaluated more positively in the more skeptical region.

Bus drivers who expected the project to be a **trial** rather than a market entrance activity seemed to be less frustrated or disappointed with problems and outages, and showed more positive acceptance levels over the period of the research. A general refusal to accept the technology and the project was not evident in the sample of bus drivers interviewed. As a few bus drivers seemed to have quit the trial, this conclusion might not be representative for all bus drivers.

5. "FCH buses are an option" – Analysis of the **Stakeholders**' acceptance

5.1. Who are the stakeholders?

The CHIC research approach on social acceptance of FCH buses in public transport considered the expectations, experiences and feedback of people involved or affected by the project activities in the regions. The interviewees were personally and directly involved in either the **core project team** (CHIC partners and regional project partners being responsible for planning or implementing projects in the regions), or in the **project environment,** facilitating the demonstration activities or being to some extent affected by it. Bus drivers were an important part of the core project team or the project environment (depending upon the regional project design), their perspective has already been discussed in Chapter 4.

Stakeholders interviewed in the regions and considered in this chapter are

- **CHIC partners:** project leaders, public transport, technology suppliers, regional staff / service technicians, supporting organizations – core project
- **regional project partners:** bus operators, research institutions, regional hydrogen project / network partners, consulting companies – core project
- **project environment:** politics and administration, fire workers, colleagues and supervisors in CHIC partner organizations, regional hydrogen network partners, critics

In some of the regions, interviewees reported on a change in role in the CHIC project, from regional project partner to a more peripheral project environment role. Whether this change was perceived as a "backwards step" or not, depended upon the individual situation. It did not however result in decreased technology acceptance, but in some cases influenced acceptance of the project negatively. In any case, in was often interpreted as being *"a pity"* and a *"missed opportunity"* leaving expertise and personal capacities unused.

5.2. Acceptance levels at the time of interviews

The acceptance level of FCH buses and hydrogen infrastructure at the time of the interviews with selected stakeholders in the five regions under investigation were diverse and reflect a broad range of individual perspectives, expectations and experiences amongst the interviewees. Not every interviewee was able to comment on all aspects of the projects, as their personal contribution to the project was limited by time or functionality/ role.

To sum it up, FCH buses were seen as "an option", either

- **already** a (serious) alternative to other bus technologies and fuels, or
- **only** an alternative, still having to compete with alternative technologies and fuels.

It is important to understand that the acceptance levels of the interviewees did not necessarily align with the acceptance levels of their organizations or institutions; they reflected and evaluated the technology and the project according to their personal expectations and experiences with the CHIC project and technologies as well as with other or previous experiences. It was a central scope of the interviews to assess personal views in order to avoid conflicting situations for the interviewees if their personal opinion deviated from the "official" version. Personal views within an organization could hinder the implementation of the project and the technology. On the one hand, sometimes people had to be convinced or continuously motivated to participate in the project, in itself a time consuming matter. On the other hand, sometimes the motivation of some people within participating organizations was significantly higher than the overall motivation of the organization. These people were struggling with organizational structures and/ or processes that had to be adapted individually to the project and the activities.

5.2.1. The core project

An overview on the acceptance levels of the core project partners (CHIC and regional project partners) at the time of the interviews are presented in Table 10. The tendencies of the acceptance levels, visualized by the arrow in the table, will be considered in more detail in Chapter 5.3 "Influencing factors in the acceptance process".

Table 10: Acceptance level of interviewees in the core project, n=43

Object of acceptance	Level	Description of acceptance
The project initiative demonstrating hydrogen technologies in public transport	++ →	Supportive acceptance, with a focus on the future potential of the demonstrated technologies: green hydrogen, zero emission public transport, independence from oil prices, new business cases, support and development of the local energy sector.
Project implementation on a regional and CHIC level	+ / - ↘	Project acceptance was varied and depended upon the role and the responsibilities of the interviewee in the implementation process as well as on the regional project design. In relation to regional project implementation it can be summarized that supportive regional networks and participation processes increased acceptance, whereas stagnant information flows within the core project or between core project and project environment, as well as the resulting (perceived) loss of decision-making and responsibility decreased acceptance. In relation to the CHIC project implementation (international project level) it can be summarized that administrative and organizational effort related to the proposal and reporting duties were evaluated being high, especially if not consistent with internal/ pre-existing evaluation and reporting structures or inflexible in adaptation. The benefit of some aspects of the CHIC networking approach was not (yet) seen with some of the interviewees.
Technology potential Hydrogen as a fuel alternativel	++ →	Technology potential and consequently the evaluation of long-term benefits were only marginally addressed and (besides a cost discussion) not questioned in the interviews. As some of the interviewees had decided upon the technology set up and the project implementation, a supportive acceptance within this group of interviewees was expected.
FCH buses to be operated in the regions	+ ↘	Discussion about the FCH buses dominated the interviews. The bus was evaluated ambivalently by the interviewees; a final judgement was not offered. At the times of the interviews people were still positive but observant, criticizing reliability and slow progress.
HRS technology	++ →	Hydrogen stations were only a marginal topic at the time of the interviews. Interviewees seemed to be satisfied with the station and the refuelling situation. The acceptance level was strongly influenced by performance of the station, so that acceptance level might change with time.

Cost	- →	Technology cost was discussed as a critical factor negatively impacting the acquisition of regional or local funds. A reduction in the cost of the technology was seen as a prerequisite for acceptance of the technology in the future. According to the interviewees, the cost at the times of the interviews did not allow for a broad-scale implementation in public transport and severely risked market introduction.
Safety	o/+ ↘/↗	Safety issues were perceived as being important to the acceptance process of the project environment and the general public. The resulting safety demands were either self-defined or defined by the project environment (internal and external). It remained unclear, how safety issues themselves influenced the acceptance process of the core project team. Safety demands of the project environment were perceived as being too extensive by some interviewees, resulting in a decrease of acceptance due to increased work load.
Funding situation	++ →	The EU financial support was seen as an important signal to increase regional willingness to commit.

++ = supporting + = agreeing **o** = tolerating - = criticizing -- = refusing

5.2.2. The project environment

An overview on the acceptance levels in the project environment at the time of the interviews is presented in Table 11. The tendencies of the acceptance levels, visualized by the arrow in the table, will be considered in more detail in Chapter 5.3 "Influencing factors in the acceptance process".

Table 11: Acceptance level of interviewees in the project environment, n=46

Object of acceptance	Level	Description of acceptance
The project initiative demonstrating hydrogen technologies in public transport	++/o →	The high acceptance of the project initiative can be seen throughout the project environment (sympathy to support). With regard to intention of the project, no arguments against the initiative were discernible. Some did believe that participating in the project was "wrong prioritizing" in the context of regional challenges and the use of public funds.
Project implementation on a regional and CHIC level	+ / - ↗ / ↘	Project acceptance was varied and depended upon the role and the responsibilities of the interviewee in the project implementation process. As with the core project partners, it can be summarized that supporting regional networks and participation processes increased acceptance, whereas stagnant or insufficient information flows (content and frequency) between core project and project environment, resulted in a (perceived) loss of decision-making and responsibility and therefore decreased acceptance. The CHIC project implementation (international project level) was hardly addressed in the interviews with those in the project environment, which focused more on the regional perspectives of the implementation process.
Technology potential Hydrogen as an alternative fuel	++/- →	By comparison with the interviews with the core project partners, interviewees in the project environment focused on the technology concept rather than performance. Attitudes and acceptance levels were varied, from supporting to lacking. In particular interviewees were ambivalent about the notion of long-term benefits and short-term costs. The apparent stability in the level of acceptance level might indicate a lack of information on project progress (unchanged evaluation situation), or might be due to an understanding, that the project did not (yet) reflect the future potential of the technology.
FCH buses to be operated in the regions		FCH buses were only marginally addressed and discussed in the interviews in the project environment. This might be due to the fact that interviewees seem to lack practical experiences with the technology and information on project progress. The interviews with stakeholders in the project environment (including critics) focused more on the technology potential rather than on evaluating the technology.

HRS station to be operated in the regions		HRS stations were only marginally addressed and discussed in the interviews in the project environment. This might be due to the fact that interviewees seemed to lack practical experience with the technology and information on project progress. The interviews with stakeholders in the project environment (including critics) focused more on the technology potential rather than on evaluating the technology.
Cost	- →	Cost of the technology in the project was critically discussed in the interviews. Compared to the cost discussion in the core project interviews, future cost was less prioritized within the group of sympathetic but less involved interviewees.
Safety	+/- ↗	The discussions on safety issues were divergent within the project environment: The attitude of some of the interviewees was (as with the general public) trustful, assuming the technology was safe/ safety was guaranteed. Others focused on safety issues, as they were responsible for handling the technology or ensuring its safety. These interviewees evaluated cooperation with the core project quite positively, even if they had ambivalent attitudes to the safety of the technology. To summarize, safety related concerns were evident but not to an extent that hindered project implementation. .

++ = supporting + = agreeing o = tolerating - = criticizing -- = refusing

The HRS station was not a topic in the interview group of sceptics and critics, and the FCH buses seemed to be rather ignored than being refused acceptance.

The group of critics and skeptics was quite diverse, and showed lower acceptance levels than the “average” project environment interviewee in regard to cost, project initiative and project implementation. The evaluation of the technology concept (technology potential) was as diversely discussed as within the general project environment. The HRS station was not a topic in the interviews and the FCH buses seemed to be rather ignored than being refused acceptance. The tendency of the acceptance level was to stability and only acceptance of the implementation process seemed to have decreased at the time of the interviews.

5.3. Influencing factors in the acceptance process

5.3.1. Regional context

The five CHIC interview regions were chosen to allow for comparative analysis on the influence of regional backgrounds in the acceptance process. They differed in regard to

- economic environment
- regional public transport environment
- regional energy, hydrogen and climate protection strategies.

The CHIC project structures, time lines and funding framework were common in the phase 1 regions. The phase 0 regions participated with pre-existing infrastructures and buses that had been funded and set up in different projects outside CHIC. Stakeholders in these latter regions were able to compare project designs and provided information about the influence of the CHIC project framework on the project implementation process.

The willingness to demonstrate FCH buses in public transport might rather be influenced by the expected (future) benefit of the technology for the region or the stakeholders than the current economic situation.

The **economic environment** of a region seemed to not have influenced the acceptance process significantly. Prosperous regions and regions with a perceived or real decrease in economic well-being both participated in the CHIC project. The willingness to demonstrate FCH buses in public transport might rather be influenced by the expected (future) benefit of the technology for the region or the stakeholders than the current economic situation. The definition of the "potential benefit" itself can be influenced by the economic situation of a region, as it reflects challenges that are expected to be assisted by the new technology or hindered by it. In the CHIC stakeholder interviews, these challenges included (amongst others)

- **in prosperous regions** increase in population and resulting demand for public transport (limited road capacities in the inner cities), need for new/ other kind of jobs to integrate migrating people, change and diversification of passenger characteristics (modal split)
- **in regions with economic recession** competition for public funds, search for new business fields, set up of regional strategies

Selected stakeholders in the prospering regions explained their motivation to invest into/ support FCH technologies and hydrogen energies as *"If it was not us, who then should bear the initial cost to get this technology running and secure a sustainable future?"* This sense of social responsibility felt by the "lucky winners" should be kept in mind as one of several influencing factors in the acceptance process.

Selected stakeholders in regions facing economic recession reported on the challenge they had in convincing regional critics and sceptics, because the focus of local discussion was more the priorities for limited public funds rather than the (potential) benefit of the technology in the future. It is important to note, that it seemed to be more a lack of belief in the potential benefits that influenced the acceptance process than a lack of money. Even in the prosperous regions, interviewees of all groups (stakeholders, general public, bus drivers) talked about "value for money" and not about "money" alone. They indeed gave signals that if they saw added value, they might accept a higher cost. However, at the time of the interviews, this added value (other than environmental performance with a focus on climate protection) remained unclear to many of the interviewees.

Topics central to the regional transport discussions were reported as focussing on priority settings: Where to invest best, what challenges to address first?

The **regional public transport environment** seemed to have negatively influenced or at least impeded the acceptance process in the project environment of some regions. Topics central to the regional transport discussions were reported as focussing on priority settings *("where to invest best, what challenges to address first?").* As buses are in service for long time, every investment in a conventional bus closes the window of opportunity for new technologies to be bought for at least a decade. It has to be kept in mind that also the investment in a FCH bus requires a commitment to operate it for this period of time to avoid additional costs of replacement. It was stated in the interviews that the EU funding of these activities facilitated the regional decision on demonstrating FCH buses in public transport and positively influenced acceptance in the initial phase of the project. Nevertheless it needs to be noted that the current situation/ challenges in public transport placed pressure on the interest in hydrogen technologies, and - as a result – to some extent queried pertinence.

Pre-existing **political or economic regional strategies on energy or climate protection** were present in all five interview regions. Some of the regions had already implemented hydrogen related strategies, allowing for a direct embedding of the CHIC project into this regional strategy. Regions without a pre-existing hydrogen strategy embedded the FCH technology activities into either pre-

existing regional energy strategies and/or linked them to goals on clean transport and climate protection. An overview of the main initial motivation factors of the regions and the stakeholders to participate in the CHIC project/ projects on hydrogen demonstration in public transport is shown in Table 12.

Table 12: Initial motivation factors of stakeholders and regions

	Environment		Market	
Goal	Climate protection	Secure/ improve local air quality	Sustainable corporate/ regional management	Business development (new markets)
	Hydrogen as answer to challenges			**H_2 and FCH technologies as product**
Region interest (localized strategies)	Zero emission public transport	Zero emission public transport	Need for (new) renewable energy storage solutions	Commercialization of by-product hydrogen and hydrogen from renewable energies
Stakeholder interest (mobile strategies)	Corporate identity (green image)		Future cost optimization (reduce vulnerability to oil price fluctuation)	Gain expertise/ competitive advantage

Only a few of the interview regions or the regional stakeholders interviewed had had prior-experience with hydrogen demonstration projects in public transport. A majority of the core project partners (or initiators) however had been organized in hydrogen networks before the start of the CHIC project, but only some in regional (industry, intersectoral) networks or international networks on public transport. The interviewees in the project environment were mainly organized in regional or international networks, not necessarily related to hydrogen technologies, but also e.g. industry, public transport and political networks. The results of the interviews revealed a strong influence of networks on the acceptance process:

+ **information exchange** in these networks was reported as being fruitful, frank and honest, resulting in an increased learning curve on how to set up and run projects, evaluate technology and address challenges. Depending upon the information exchanged, acceptance might be increased or decreased.

+ **support of networks** as seen as valuable in situations when experts were needed to convince people or report on experiences (guarantors), when partners and co-funding for new projects were being sought (initial phase), and for reflection processes/ motivation.

5.3.2. Technology potential

The discussion on the technology potential of FCH buses and hydrogen stations as well as the resulting acceptance of them seemed to be influenced by **regional hydrogen strategies and the framing** of the project:

In regions without prior hydrogen strategies, awareness and acceptance of the technology potential was strongly connected to the project framing ("sales story") and project performance.

+ In **regions without prior regional hydrogen strategies**, regional stakeholder acceptance had to be initiated along with setting up the CHIC project, resulting in a comparatively high additional work load and risk for the project. The project framing ("sales story") had to be defined, focussing on climate protection, regional economic development, market development, security of energy supply or local air quality/ reduction of noise levels etc. The choice of framing influenced acceptance at different stages of the project, e.g. a regional framing focussing on regional economic benefits was only of limited persuasive power when the initiating or leading stakeholders were not located in the region or organized in regional networks. Co-funding for projects from regional funds seemed to become more difficult and time consuming without a prior regional hydrogen or energy strategy, and with less involvement of regional stakeholders. On the other hand, supra-regional stakeholders, focussing on climate protection, security of supply or market development were at liberty to offer the project to other regions when anticipating acceptance problems or problems with technology implementation in the region. *The resulting implications for the acceptance process were that in regions without prior hydrogen strategies, awareness and acceptance of the technology potential was strongly connected to the project framing ("sales story") and project performance ("technology potential").*

+ The project framing in **regions with prior hydrogen strategies** was strongly connected to the existing strategy framing ("story") and stakeholders associated with the strategy. The activities were presented as a next or necessary step to reach the strategic goals and could be embedded into available structures and networks, which reduced the amount of work necessary to communicate and convince people in politics,

Project performance was observed and evaluated more critically in regions with prior hydrogen strategies.

administration and business. On the other hand, the pre-existing framing ("story") had to be adopted; completely new or individual framing (e.g. security of energy supply instead of climate protection) was limited. The resulting implications for the acceptance process were a relatively comfortable situation for the stakeholders in the case that the project framing aligned with the pre-existing strategy and performed according to expectations. Awareness and acceptance of the technology's potential remained connected to the overall hydrogen strategy, and was evaluated independently of the individual project performance. Project performance was observed and evaluated more critically, especially if project related activities were perceived as potentially risking the overall strategy ("*running a project successfully might kill the idea*"). This seemed to be especially the case when project interest and design did not align with regional interests and strategies (such as time lines, partners, activities, framing etc.).

The regional framing ("stories") were multidimensional and often emerged with time.

The **framing of the project and the activities in the interview regions** ("story") was multidimensional: the use of hydrogen for public transport was connected to several sub-stories and it was not always clear, if these stories were deliberately developed or if they emerged with time. Most of the stories influencing expectations and resulting acceptance seemed to be drafted by the initiating stakeholders and complemented by stakeholders in the project and the project environment. The story was used to explain the

- need to support the implementation of hydrogen technologies into public transport (technology framing),
- motivation of the region to invest into this technology at this early stage/ before market introduction (regional framing),
- stakeholders' role in the project and the role of the project in the innovation process (project framing).

The technology framing aiming at long-term goals and technology potential seemed to be broadly suitable.

The reasoning for the **need to support the introduction of FCH technologies** into public transport aimed at long-term goals and the potential of the technology. In particular clean hydrogen (production), zero-emission public transport (application) and independence from oil price/ security of energy supply seemed to be stories in all regions, independent of existing hydrogen strategies. The **technology framing** seemed to be broadly suitable.

The **reasoning for the regional stakeholder motivation** to participate at an early stage of technological maturity (answering the question as to why a region accepted additional cost and efforts fostering a technology to be commercially available in the future) was also seen in terms of long-term benefits including

- developing new markets (selling surplus hydrogen, selling renewably produced hydrogen or using hydrogen as storage in the context of energy services to the grid, increase competences and understand customer/ market demands and expectations),
- forming and extending a positive image (corporate identity, corporate social responsibility, regional image – being environmentally, innovative, responsible),
- influencing the innovation process to ensure an optimum technology performance meeting the needed characteristics and adaptability to regional specifications (integrate market demands).

The regional framing refined global goals to the regional level. Regional framing was important for raising and keeping the acceptance of stakeholders and the general public.

These arguments were specific to the regions and refined the global goals down to the regional level. The **regional framing** ("story") was identified as being an important influencing factor for stakeholders' (and to some extent the general public's) acceptance. The willingness to accept and support an unknown/ unused technology application seemed to be higher when it was embedded into a regional context, as a part of a longer history and strategies. The technology solution then appeared more familiar and logic to the regional stakeholders, who supported their underlying regional interests. At the same time it led to criticisms and a decrease in technology acceptance in the group of stakeholders disapproving of the underlying regional strategy or interests, as shown in some of the interviews. The discussion on the technology or the project became a debate on principles.

The **stories reflecting the individual and the project's role** in the innovation process can be summarized to the following two perspectives:

- Considered the CHIC project as a **"trial"**, aiming at the technology evaluation and optimization under real-life conditions. Readiness for marketing seemed reasonable but not yet reached.

+ Considered the technology demonstrated in CHIC as pre-commercial and with limited teething problems. The project was perceived as a **"public transport project"**, as a possibility to gain experiences with the daily operation of the technology, reliability and mileages are key factors in the evaluation of success.

The project framing positively influenced acceptance whenever it was defined as a trial.

The acceptance of the technology seemed to be influenced by the underlying **project framing**. Whenever the trial was in focus, people seemed to tolerate problems and setbacks as an integral part of the innovation process, whereas a decrease of project acceptance could be noticed in situations where interviewees expected market-readiness or the project reflecting a continuous progress towards commercialization and seemed to be disappointed by the apparently slow progress of the innovation process.

Finally it can be stated that the framing of the project and technology based upon the potential long-term benefits was hardly discussed within the inner stakeholder group. The less involved interviewees were in the project at the time of the interviews, the more clearly they questioned long term benefits and addressed the need to evaluate and verify assumptions and goals.

Safety issues of FCH technologies predominated in the stakeholders' interviews. One interviewee stated that *"safety issues closely correlate to hydrogen"*, summing up the perspectives of many of the stakeholder interviewees. Actually, safety issues seem only to be an issue for the stakeholders' group, despite the expectation of it being an issue of similar importance to all people involved in the project or using the technology. At least in the pre-test interviews, challenges to secure and increase acceptance in the public and among the authorities were expected. Whenever opposition was expected, then safety issues were seen as an issue. To many of the interviewees it was surprising that people did not see safety as an issue. When the results of the interviews with the general public are considered, the lack of opposition (and concern) on safety grounds was not mere chance but based upon the expectation that technologies that are introduced into the market were safe. People did not seem to be unduly worried as they delegated responsibility to the stakeholders/authorities in charge of the project and the technology implementation.

Several stakeholders stated securing safety was a challenge whenever user and usage systems change. The use of hydrogen in public transport resulted in bringing an industrial technology to public zones. Instead of highly qualified employees being used to handle the technology, people without (or with only limited) understanding of the technology become users of it. The changes that the new technology and station design were reported to have to cope with in order to be implemented in a non-industrial site are summarized in Table 13.

Table 13: Changes necessary in the handling processees of hydrogen due to its implementation in public transport

Industrial sites	Public sites
+ Production and filling of hydrogen happen only in restricted areas, handled by highly qualified/ experienced personnel, the works fire brigade is responsible in case of incidents	+ Production and filling of hydrogen happens at a public filling station, handled by private/ inexperienced users, the public fire brigade is responsible in case of incidents
+ Transport of hydrogen only in labelled hazardous-cargo vehicles (easy to identify in case of an accident)	+ Hydrogen as a fuel is invisibly and widely used in private and public vehicles (difficult to identify in case of accidents)
+ Supervised private territory, with only limited access	+ Open-access to territory, interference or demolition possible

An additional challenge to the technology implementation in public and individual transport was reported as the **still limited experience of regional stakeholders** responsible for the implementation and authorization processes at the times of the interviews. Some interviewees estimated that the lack of experience in safety related and authorizing issues in this group could not be remedied by a simple information exchange but required national or international safety regulations, standardized processes and centralized information flows. Without these supporting structures, implementing FCH technologies remained complicated and time consuming for applicants, authorities and the fire brigade. Ambiguous regulation, safety concerns and a lack of experience can be summed up as negatively influencing the acceptance process, as they not only resulted in an uncertainty among the regional stakeholders but also in supposedly “over-engineered” safety measures, as stated by the interviewees.

5.3.3. Technology characteristics and performance

The project was on-going at the time of the interviews thus interviewees could not say if expectations of technology potential had been met or not.

The acceptance of the FCH buses was significantly influenced by pre-project expectations and the regional framing ("story") of the project. The project was on-going at the time of the interviews thus interviewees could not say if expectations of technology potential had been met or not.

The conclusions drawn about the **influencing factors on the acceptance of FCH buses** were mainly based upon interviews with regional project partners and to some extent with interviewees in the project environment. The latter were less specific in their feedback due to a lack of experience with the concrete product. The acceptance level before the arrival of the buses had been in principle supportive (high). The regional project partners (including CHIC partners in the region) were aware of the fact that the implementation of the buses would be challenging, resulting in a generally positive and sporadically sceptical attitude. The size of the expected challenges seemed to be determined by prior experiences with the introduction of new bus technology concepts (with and without alternative drivetrains/ fuels) and the framing of the CHIC project as a trial requiring a "pioneering" spirit.

- Stakeholders, whose expectations weren't reached due to delays in bus arrival, and technical problems and outages resulting in a lower reliability of the buses than envisaged, showed a decrease in acceptance ("We expected problems but not to that extent").

- Stakeholders, who experienced "tolerable delays" of deliveries of the buses and "less problems / outages than feared" seemed to be more confident with the technology. Framing the project as a trial supposedly attenuated frustration and positively influenced acceptance in these regions.

Whenever problems occurred and solutions were promptly implemented, people were satisfied and confident and evaluated problems as "part of a trial".

It is important to understand the close relationship of technology acceptance and project processes in this context. Whenever problems occurred and solutions were promptly implemented, people were satisfied and confident and evaluated problems as *"part of a trial",* whereas the acceptance level of interviewees who reported on (perceived) interminable periods of problem solving seemed to be decreased.

The **specific costs** related to the technology concepts implemented in the regions (FCH buses, hydrogen production and HRS stations) were a central topic in the interviews. Within this discussion project related costs were addressed as well as the potential future costs of implementing FCH buses into public transport. FCH technologies were seen as being at a disadvantage in regard to their cost in the following ways

- hydrogen buses compared to other bus technologies
- FCH buses compared to ICE hydrogen buses
- green hydrogen from electrolysis compared to other (green, by-product or conventional) hydrogen production processes.

Technology potential was not seen to legitimate any size of additional cost. Cost turned out to be the "gate keeper" of the framing and the acceptance process.

The interviewees pointed to the fact that regional stakeholders' financial support of the CHIC project activities did not reflect a generic acceptance of the higher cost. Technology potential was not seen to legitimate any size of additional cost. Added value and potential benefits of the technology were perceived as being less personal and more generic than among the bus drivers, improvements to the work environment of the drivers or the comfort to the passengers were not a topic in the interviews. At the time of the interviews the cost was seen as decreasing acceptance by a majority of project partners and interviewees in the project environment. In fact it turned out to be the "gate keeper" of the framing and the acceptance process.

The higher cost of hydrogen technologies (investment and operation) compared to other bus technologies resulted in an increased work load for the project partners who were responsible for communicating and justifying the project initiative. This occurred both – internally as well as in the project environment, the general public and the media. Interviewees reported on a repeated need to address questions related to the technology and project cost, and **discussions on opportunity cost** (e.g. using money for more urgent issues in the region and in public transport, *"they could have invested the money to buy more conventional buses, relieving pressure on the tight schedules")*. To acquire regional and stakeholder co-financing of the project, strong personal motivation and considerable power of endurance as well as creativity in identifying funds were needed. In addition, willingness to take a risk and personal responsibility seemed to be important personal characteristics of the stakeholders who initiated the project.

EU funding was estimated important not only to reduce the regional contribution to the overall project cost but to give a signal on the importance of the technology.

The **role of EU funding** in this context was estimated to be of utmost importance to the supportive acceptance of regional stakeholders. The EU funding not only reduced the regional contribution to the overall project cost, but gave a signal about the importance of the technology and the project which resulted in a more cooperative attitude from potential sponsors.

The cost of the technology in the future would have to decrease to an acceptable level according to interviewees – placing the buses front and centre of the debate. FCH buses would have to compete with alternative bus technologies, and not with other electric means of transport. FCH buses were not perceived as being interchangeable with e.g. tramways or trolleybuses, as these possessed a considerably higher passenger load. This ability to take a higher passenger load along with the regional attachment to the tramway was seen as justifying the higher cost of these transport modes (*"the citizens would never accept giving up the tram", "they like it for historical reasons, it has always been part of the region", "I feel home when I see the tram"*).

The **cost of hydrogen production and the HRS operation** was hardly addressed by the interviewees. Potential cost reduction of alternative production pathways for "green" hydrogen or centralized concepts were not discussed, although some interviewees mentioned that on-site electrolysis was not the cheapest solution. The tendering framework required by CHIC and the overall project timelines and decisions in the original proposal seemed to anticipate certain hydrogen pathways and technology concepts without being customized to the regional contexts. As long as hydrogen was only considered as a fuel for public transport and did not have to subordinate to regional strategies (e.g. as storage for renewable energies), alternative technology concepts were expected to result in a cost reduction on the infrastructure side. *In the context of the economic crisis, this cost discussion was expected to impact more greatly in the future and risk technology acceptance.*

Although the technology potential and concept seemed to be convincing, technology performance resulted in a more cautious and "wait and see" attitude of stakeholders.

The comparative evaluation of bus technologies reflected the technology performance and reliability at the time of the interviews. Although the technology potential and concept seemed to be convincing, technology performance resulted in a more cautious and "wait and see" attitude. Further optimization, experience and analyses would be needed to finally decide upon whether to go forward with the technology. Regional stakeholders evaluated FCH buses as being an option for clean transport that

had not yet reached suitability for daily use. Once the technological challenges that were faced at the times of the interviews were overcome, the need for large European bus fleet projects would become important to systematically evaluate different HRS and operational concepts.

Today's technology performance of the HRS was, again, only addressed and discussed by some of the interviewees. At the times of the interviews, experience of the hydrogen station were limited for most of the interviewees, especially in the project environment, and resulted in discussions on the technology concept rather than performance. Here, safety issues and authorization dominated the discussions. According to the interviewees involved in the hydrogen infrastructure set up and operation, teething problems has been expected and were experienced, but could be handled without too greatly disturbing the bus operations at the time of the interviews. As with the commitment of the bus operators to reduce impacts on the passengers due to outages, securing station operations resulted in unexpected additional work loads.

The only feedback on **HRS design** was provided by the bus drivers and the technicians in the workshops. All other stakeholders did not seem to be very affected by station design. One interviewee stated that despite architectural conventional wisdom, form should follow function and not vice versa.

5.3.4. Project structures and processes

At the time of the interviews, most project activities in the phase 1 cities had been focused on implementing the technology into the public transport service. The phase 0 cities already had had much longer experience of FCH buses and HRS in operation.

Three main influencing factors on the acceptance process of the stakeholders could be seen as resulting from the project design and set up:

- Changes in routines and duties
- Level of information exchange
- Level of integration into regional structures (networks)

Changes in routines and duties were considerable for all regional project partners and some of the stakeholders in the project environment. Changes in routines and duties resulted in different activities than used to or an increased work load for the people directly involved in the project. Some interviewees stated that they had been employed specifically for the project (so new routines were set up, no routines were changed), others reported on a continuous additional work load and several other responsibilities besides the hydrogen project. A third group of interviewees was integrated at certain times during the project implementation, either once or repeatedly (e.g. authorities, controlling department, purchasing department, politicians/ administration, and others).

The project partners responsible for procuring, implementing and operating the FCH buses and the HRS reported on **changes to responsibilities and routines** in relation to

- **Project coordination (regional level):** Considering the needs, interests and expectations of a wide range of people involved in the project processes or the regional project implementation was time consuming and challenging. This was largely because it was generally attended by an inherent lack of managerial authority due to the project set up (internally: colleagues in other departments, externally: partners in other organizations and institutions). It was reported that it was important to have “powerful seniors” or other persons of authority, who could back up the different stakeholders based upon their personality

and experience. Some regions were (temporarily) supported by externals, who were responsible for consolidation and project set up / implementation.

+ **Procurement of the buses and the HRS:** A lack of expertise in procuring hydrogen buses and refuelling stations was a common challenge to the procurement process: the definition of product characteristics and expected performance in the demonstration phase had to be prepared and aligned with internal procurement processes and regional needs for public transport. Public transport authorities who usually weren't responsible for procuring buses but only for procuring public transport services (leaving it to the bus operators to buy the buses) had to implement these processes for the first time. They had to rely upon external information and experience. It was reported that the procuring period for buses exceeded the procuring period for bus operators (being responsible for operating the buses), so including the expertise and needs of the future user was not possible or presented additional challenges. Problems experienced with the buses that were not hydrogen-related, might have been avoided if the expertise and needs of the future users had been included at a very early stage of the project.

+ **Project implementation (CHIC level):** The additional work load and consequences from changes in internal and external responsibilities due to the requirements of the CHIC project framework had been underestimated by all interviewees. Keeping the buses running was reported as very time consuming, as the maturity level of the technologies required continuous information exchange and activities within the project and with the regional project environment. The effort needed for the CHIC reporting system was seen as being high, and could be improved by more supportive means of data acquisition or optimized processes.

+ **Bus operation:** The actual filling time for the buses was perceived as being less important than the time needed to reach the refuelling station (if not on the bus depot) and the fact that the location of the station was not allowing for an integrated servicing process (e.g. filling and cleaning at the same time). The additional time for dispatching buses and drivers related to the need to consider changes to the shift models (integration of filling times, qualification of drivers) on the one side and the level of reliability on the other side (doubling capacities, replacing buses).

+ **Customer relation:** The infrastructure suppliers reported general challenges due to the shift of market and customer

characteristics. They had been used to industrial customers, now they were facing customers from the private or the public sector. The technology design and operation had to be adapted to the laymen's needs, posing different safety situations and consequently requiring new safety concepts and measures. The relationship of public transport authorities/ bus operators and bus suppliers also changed in the context of the project. Either new suppliers were chosen to deliver the buses, resulting in completely new administrative and communication processes at the local transport authority, or the pre-existing relationship had to be enlarged to include the project. The new cooperation model (bus supplier – transport authority) was reported as challenging and confusing in situations where existing and new structures and processes intersected and responsibilities or contact people changed or overlapped. The regional contact persons became the interface of the bus operator/ public transport authority and the research department of the bus supplier, and required a different and more time consuming customer relationship than with serial buses.

Additional efforts were not necessarily perceived as burden, but also as a (positive) new experience, enhancing boring processes and enriching personal life.

Changes in routines and responsibilities were frequently discussed in the context of additional efforts. **Additional efforts** did not seem to automatically result in a decreased acceptance. They were not necessarily perceived as burden, but also as a (positive) new experience, enhancing boring processes and enriching personal life. For the acceptance process, it seemed to be more important that

+ **additional efforts** had been adequately estimated and sufficient resources were provided. The acceptance level of interviewees who felt that the effort was "underestimated and intense" seemed to show reduced acceptance.

+ **responsibilities and boundaries** were well defined in order to avoid conflicting situations.

Into the future, challenges in regard to routines and responsibilities were anticipated to be

+ **re-defining filling procedures** (the filling of the hydrogen buses would have to be integrated into the overall servicing activities of the buses, reducing time and effort for filling when the share of hydrogen buses in the fleet increased).

+ **decisions on operation and ownership models of refuelling stations** (operating filling stations and on-site hydrogen production plants was considered not to be core activities

of a bus operator. At the times of the interviews neither the bus operators/ transport authorities nor the infrastructure suppliers seemed to envisage a future role as station operator).

Changes in routines and responsibilities also resulted in situations of uncertainty, when people did not have access to the information required to handle the situation.

The accessibility of information (information flow) and the exchange of information seemed to be a major influencing factor on the acceptance process in the group of stakeholders.

The accessibility of information (information flow) and the **exchange of information** seemed to be a major influencing factor on the acceptance process in the group of stakeholders. As the project implementation process required activity and support from stakeholders at different project levels (CHIC project, regional project, project environment), up-to-date information in a stakeholder relevant format (content and level of aggregation) was seen as mandatory to empower people and keep acceptance as well as motivation high in support of the project. It was evident that throughout the regions the level of information significantly decreased from the inner project circle to the wider project environment, as well as with project progress.

- Many stakeholders (project environment) who had been important in the initial phase of the project (e.g. politicians, administration and funding institutions) stated they received an unsatisfactory level of information, feeling excluded from the project progress and lacking up-to-date information.
- Some interviewees (regional project) felt there was an insufficient information flow within the project and between suppliers and operators. Inexplicably long periods to implement solutions to problems as well as a lack of information of project progress were reported.
- Some interviewees expressed their frustration about when feedback they provided to the project seemed not to be considered in the project and technology implementation processes.

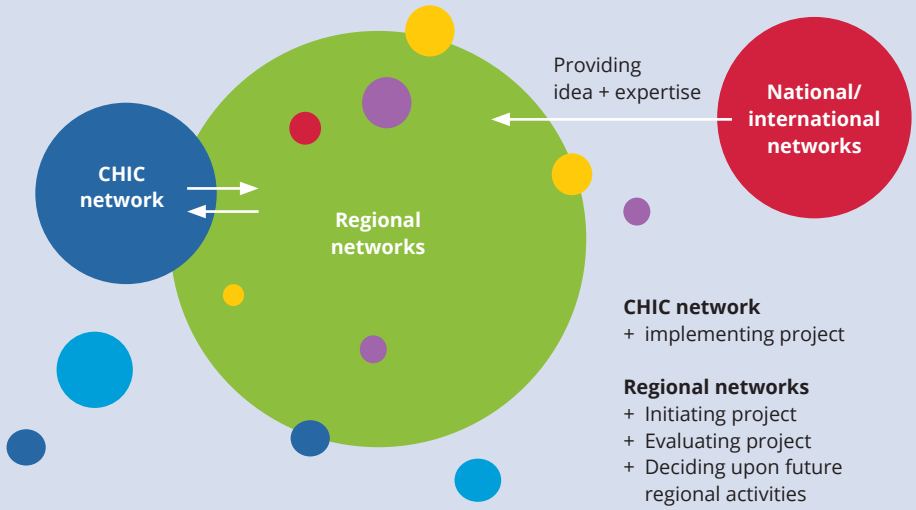
Not being able to reply to questions from the general public, the media or political stakeholders about the project progress and performance risked embarrassing situations for stakeholders being responsible for initiating and supporting continuation of FCH activities.

It is important to understand the implications of a reduced information flow/ exchange on the acceptance process. The project initiators and supporters in the project environment were important decision-makers and multipliers/ disseminators of the project idea given their personal association with the project. Not being able to reply to questions from the general public, the media or political stakeholders about the project progress and performance risked embarrassing situations. In the longer term, these stakeholders are needed to initiate and support the continuation of further hydrogen project activities. In the short-term they assist in keeping people in the second-tier updated and motivated. It seemed as if these important regional stakeholders, who were well informed in the beginning of the project (initial phase and start of operations), were "lost" at some point in the process, when activities to keep the project and the buses running increased and urgent issues overlapped important issues. Interestingly, this same causality seemed to happen to the information flow from suppliers to operators and regional project responsibles.

The level of information was an important factor in the acceptance process of the stakeholders as it directly influenced decision-making and responsibility. A lack of information seen as being important for the personal situation decreased acceptance.

The **level of project integration into existing regional structures (networks)** directly and indirectly influenced the regional acceptance processes in the interview regions. The importance of pre-existing **national or international networks** for the initial phase of the project was emphasized by the interviewees, as regional stakeholders had been introduced to the project idea, the technology potential and central hydrogen stakeholders by their networking partners (sharing information and acting as a guarantor). It seemed as if in the beginning of the regional hydrogen activities, national or international close personal contacts and the commitment of individuals to set up a regional hydrogen technology trial, were key to the successful initiation of the project and the development of the project idea. Pre-existing **regional networks** on the other hand became increasingly important in the process of realizing the project idea (financing, expertise and other support activities). Finally, the CHIC project activities resulted in a **project network** with regional, national and international project partners that partially integrated players and stakeholders from the pre-existing regional networks (Figure 3).

Figure 3: Relevance of networks for the acceptance of the project implementation



The interaction of the regional structures/ networks and the project structure influenced the acceptance process of the regional stakeholders

+ **positively**, whenever a close and trustful cooperation of the CHIC network and the regional networks resulted in an intensified information exchange, empowering stakeholders in different regions to comprehensively evaluate the technology performance and potential, and commonly identify challenges and solutions. The stakeholders of the demand side (public administration, transport authorities, bus operators etc.) profited from the expanded network by an early and frank information exchange on technology performance and organizational learning, thereby strengthening their position towards the technology suppliers. Their argumentation towards regional skeptics and critics became more convincing by referring to activities and experiences in other regions (guarantors).

+ **negatively,** whenever the initial (regional) network wasn't or did not feel sufficiently integrated in and informed by the CHIC network. In some regions, the CHIC network seemed to depart from the regional network, focusing on the project implementation and neglecting regional interests and the overall strategy.

The **role of networks** in the process of implementing FCH buses and HRS stations into public transport was seen in the trustful cooperation reported being specific to longtime networks. The technology development as well as the introduction of a complete new technology system into a running system required not only expertise, but also trial-and-error activities and risk taking when identifying and applying new processes. It seemed as if stakeholders were more likely to take new paths when they knew that making mistakes was accepted. This was apparently the case in the longtime (regional) networks, as well as in business cultures of some of the stakeholder organizations.

5.4. Preliminary conclusions

A central finding of the CHIC research on stakeholder acceptance is the apparently strong correlation of expectation and project framing, resulting in the need to actively manage expectations and increase related activities in the future. This is especially important when not only the project success is at stake but also the future acceptance of hydrogen activities in the region. The results of the interviews indicated that project partners and stakeholders in the project environment evaluated their project experiences and the technology performance relative to their prior expectations. Some central expectations seemed to not have yet been fulfilled at the times of the interviews, and although interviewees explicitly stated that this hadn't resulted in a decrease of technology or project acceptance so far, it was obvious that they were awaiting the fulfilment of their expectations by the end of the project. Their final evaluation would then be the basis for decisions on further commitment and support. The influence of technology and project framing and expectations on the acceptance process of stakeholders can be summarized as potentially strong but without significant impact at the time of the interviews due to the interviewees sympathetic attitudes. This attitude could be interpreted as a "vote of confidence", based upon the technology concept and the regional framing.

6. "A bus is a bus..." – Analysis of the **general public**'s acceptance

6.1. Characteristics of the general public sample

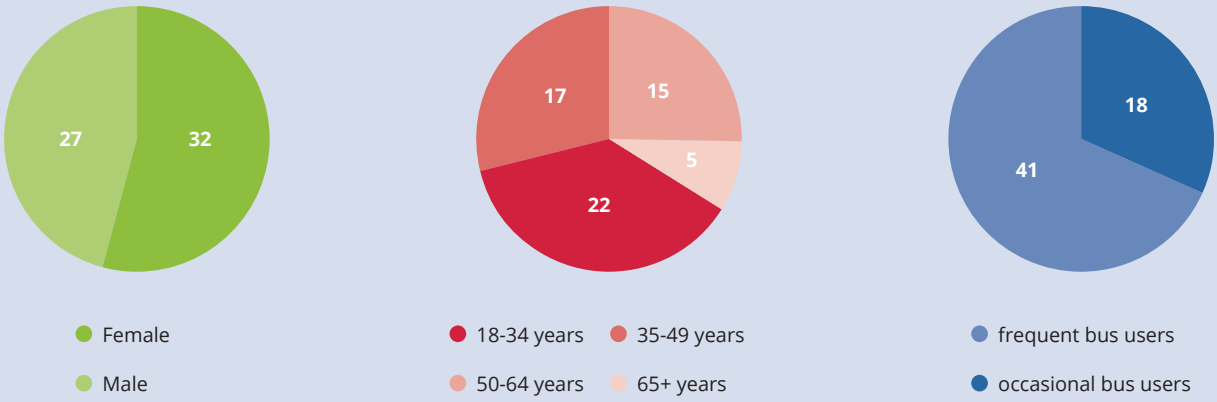
The selection of the citizens participating in the CHIC interviews reflected the research approach to understand the acceptance process of the general public. Due to the small size of hydrogen bus demonstration fleet and the timing of the interviews (within several months after starting operation in phase 1 cities) it was expected that visibility of the hydrogen buses was still too low to allow for a representative selection of citizens. To increase possible awareness it was decided to focus on people

- living or working at the hydrogen bus lines, and
- regularly or occasionally using buses in public transport (excluding people who were not using public transport at all)

in order to have a "best case" sample allowing for an evaluation of visibility and neighbourhood reactions to the buses and the hydrogen infrastructure. *Thus, the results of this analysis have to be seen through a filter of a non-random sample potentially leading to a more "favourable" interpretation or reflecting a higher penetration of FCH buses.*

The sample characteristics in the five CHIC interview regions are shown in Figure 4.

Figure 4: Sample characteristics of the general public interviews (2012-2013), n=59



As most of the citizens weren't aware of the technology concepts and the hydrogen project(s), additional information was provided in the interviews to allow for an analysis of acceptance levels and influencing factors in the acceptance process. Sporadically, interviewees referred to existing knowledge from school or work, or due to an individual interest in alternative drives and fuels. Most of the pre-existing knowledge could be classified as being rudimentary or out-dated, so that this group also was introduced to the main concepts and characteristics of the hydrogen technology to enable a discussion on the issues.

6.2. Acceptance levels at the time of interviews

The acceptance of the hydrogen buses in public transport was generally positive. The interviewees either tolerated or supported the activities. Depending upon the region, people were enthusiastic to indifferent; none of the interviewees disapproved of the project or the technology. The acceptance level of the hydrogen station could not be evaluated, as the interviewees had not noticed or seen the station before the interviews.

Table 14: Acceptance level of citizens in five CHIC regions, n=59

Object of acceptance	Level	Description of acceptance
The project initiative demonstrating hydrogen technologies in public transport	++	Regarded with favour, at a very low overall awareness level of the project initiative (partners, goals, activities). A guided discussion revealed a strong support of the initiatives goal to improve the environmental performance of public transport. Energy security of supply was of marginal interest. In some of the regions, citizens spontaneously mentioned expectations of mid- to long-term economic and regional advantages from the initiative.
The project initiative partners and supporters	+	The regional consortium, as a publicly visible project structure, was evaluated as neutral to positive. In particular the size and diversity of the stakeholders (companies, politics, research institutes, interest groups), and single stakeholders were perceived as guaranteeing for the success of the initiative.
Hydrogen as an alternative fuel	+	A significant part of the interviewees questioned the environmental benefits of hydrogen, especially if the origin of the hydrogen was not from renewable sources. In one region it was explicitly mentioned that nuclear power would not to be accepted as an energy source.
FCH buses to be operated in the regions	++/ o	The interviewees prioritized other challenges/ duties of public transport: hydrogen buses were seen as being of secondary importance after securing reliable and affordable services ("a bus is a bus"). As soon/long as these services were provided, environmental improvements were appreciated and supported.
Cost of clean transport	o	The awareness of cost seemed to be very low and with no influence on the acceptance at the time of the interviews. Some details in the interviews indicate that cost might become an issue in some regions or in the future, and decrease acceptance if it resulted in competition with other regional spending or higher ticket prices.
Safety	+	No concerns were noticeable. Safety was a side issue in the interviews. When addressed, risk was perceived as being acceptable.

++ = supporting + = agreeing o = tolerating - = criticizing -- = refusing

Compared to the bus drivers, the feedback from the general public was considerably vaguer. The regular use of FCH buses, the experience with other alternative bus technologies and the higher involvement in the project resulted in a significantly higher number of topics being raised by the group of bus drivers. The citizens interviewed possessed too little information to get an idea of the topics that might allow them to evaluate issues spontaneously. Only with a guided interview, introducing technology concepts and project motivation, did a discussion occur that allowed for an analysis of influencing factors on the acceptance process.

6.3. Influencing factors to the acceptance process

6.3.1. "A bus is a bus" – Discussion on the role of public transport

The project initiative was unanimously appreciated by the interviewees; they acknowledged that *"finally somebody is taking action"*. In particular, the potential environmental benefits resulting from the use of "green" hydrogen are considered as praiseworthy.

The results of the interviews with the general public indicated a strong relationship between the acceptance of FCH buses and the perceived quality of public transport service.

Nevertheless, the results of the interviews with the general public indicated a strong relationship between the acceptance of FCH buses and the perceived quality of public transport service. Previous experiences with publicly funded or initiated projects seemed to also affect the evaluation of the hydrogen bus demonstration activities.

In the majority of the interview regions, the interviewees broached the issue of an **increase in demand** for public transport in the past years. According to the interviewees, public transport authorities had reacted in various ways, mainly by implementing activities to either extend or optimize services. Some of the citizens evaluated the activities as lacking a vision or as not always being productive. In only one region, a reduction of service due to cost was addressed (fewer buses on the lines). Cost issues related to the hydrogen bus demonstration activities were not addressed by interviewees of this region. Possible explanations could be that

- people were not aware of project and technology cost,
- the added value perceived with the bus technology was overshadowed the cost discussion
- the share of hydrogen buses was perceived as too little to influence the overall cost of public service.

The **overall satisfaction with the regional public transport services** was high throughout the sample. Nevertheless, the interviewees were not only positive, they discussed and criticized especially

- **Capacity of transport:** throughout the regions buses seemed to be overstretched at certain lines or times of the day. The interviewees of several regions reported that limited bus

capacities had led several times to situations where they could not enter the bus and had to wait for the next one. Passengers travelling longer distances complained about a lack of seating capacity ("must have services").

+ **Tardiness of transport:** especially bus services seemed to frequently be late, resulting in missed connections and vexed passengers. The reasons for tardiness were seen in too much road-traffic, lack of extra lines/ buses at times with high demand, too many passengers, too tight schedules, and too little buffer times to reach connections.

+ **Safety in public transport:** safety in public transport was only addressed in regard to the behaviour of other passengers or users of the public transport infrastructures. The bus technologies or services were not negatively associated with safety concerns.

It seemed that as long as the quality of service was reached, people appreciated an additional commitment of the public transport authorities to demonstrating alternative bus technologies.

It seemed that as long as the quality of service was reached, people appreciated an additional commitment of the public transport authorities to demonstrating alternative bus technologies. The acceptance level would be at risk as soon as passengers had the impression that the service was reduced or negatively impacted due to a focus on implementing innovation. Some of the interviewees mentioned bad experiences with former implementation of innovations (either public transport or other public authorities), resulting in a neutral ("wait- and-see") or sceptical acceptance level.

The interview results did not allow for differentiating acceptance levels due to regular or occasional bus usages. As people without any bus usage in the six months prior to the interviews had not been included in the sample, no conclusions on their acceptance level could be drawn in this analysis. Only a slightly higher interest in the technology among occasional bus users was determined and this could be explained by the characteristics of the sample which included more males with a technical background (interest, qualification, jobs).

6.3.2. "What is the difference between hydrogen and biogas?" – the level of information

A lack of background information seemed to not have influenced the acceptance level at the times of interviews but hinders an active positioning of people (both positive and negative).

A majority of citizens interviewed in the post-test interviews had seen or been on the FCH buses (50% each) at the time of the interviews. The high level of **awareness about the hydrogen buses** can be explained by the selection criteria of the sample (focussing on people either living or working on the FCH bus lines). Nevertheless, **background information** on the technology or the project was quite poor in the group of interviewees. A lack of knowledge seemed to not have influenced the acceptance level of the technology or the project at the time of the interviews. People either viewed the project favourably, or – in the worst case – showed no interest/ were indifferent. The interviews revealed the importance of the level of information on the acceptance process:

- The interviewees were not (yet) aware of the potential and risks of hydrogen technologies, preventing people from actively positioning for or against the technology (which might change with an increase in knowledge and reflection), and
- a lack of understanding risked misunderstanding the arguments for the project and the technology, as information could hardly be verified or falsified by common sense.

One interviewee noticed in the interview that he had referred to biogas instead of hydrogen when replying to the questions, as he perceived both as gaseous fuels with an environmental (climate) benefit. It was essential to verify the common understanding of hydrogen and hydrogen technologies in order to ensure a proper interview situation.

More than a third of the interviewees in the four post-test regions were able to recall **regional communication activities**. This occurred particularly in regions with fewer inhabitants where people seemed to be more aware of the demonstration activities. The overall project communication was perceived as having been "cautious" and "too cautious". The low awareness of communication activities did not necessarily indicate a low communication level, as some of the interviewees reflected on their own disinterest in listening or getting more information.

The message perceived by most of the interviewees was *"the buses exist" and "the technology is benefitting the environment"*. Detailed information on the project or the technology concept had not been internalized. A majority of the interviewees expressed the

The message perceived by most of the interviewees was "the buses exist" and "the technology is benefitting the environment". Detailed information on the project or the technology concept had not been internalized.

wish to learn more about the technology and the project after the supported discussion on the technology concept *(see Table 6: Interview material: Technology concept*). They were perplexed that communication hadn't been more aggressive. Knowledge about the technology potential, especially in regard to the environmental benefits, increased project and technology acceptance of the majority of citizens. At the same time they wondered and were sceptical about the reasons for the perceived low communication level:

- Why weren't communications more forceful if it was a good idea?
- Were there hidden disadvantages to the project and the technology, as they already experienced before with other supposedly environmental technologies?
- Was the region a guinea pig?

A minority of interviewees addressed effectiveness and cost-benefit of project and technology communication, stating that they would negatively evaluate oversized communication activities. Oversized communication measures were defined as measures that were either apparently very resource intensive (cost and effort) or disproportionate to the (small) share of hydrogen buses in the fleet.

The interviews with the citizens revealed **challenges to the communication** of hydrogen technologies. Only if people gain a detailed insight into technology concepts, potential and motivation of stakeholders, were they enabled to become supportive. At the same time, a more profound knowledge might also increase scepticism and an increased need for discussion and information, questioning the motivation of stakeholders, reasonability of concepts and resulting environmental benefits (climate protection, origins of resources, disposal etc.). More detailed information could therefore also (temporarily) decrease acceptance, showing that it had an important but somewhat unpredictable role in the acceptance process of the general public.

6.3.3. "Why not exchanging the whole fleet?" – technology concept and performance

The basic technology concept to produce hydrogen from renewable energy sources and fuel FCH buses in public transport convinced and enthused most of the interviewees of the general public sample.

The basic technology concept to produce hydrogen from renewable energy sources and fuel FCH buses in public transport **convinced and enthused** most of the interviewees of the general public sample. A few interviewees seem not interested as they regarded the development of sustainable transport as not being a priority in issues that had to be solved by public transport. In order to understand influencing factors in the acceptance process, the technology concept was discussed with the citizens and experiences with the FCH buses were reflected upon. Only a minority of interviewees didn't have any practical experiences with hydrogen buses and the HRS station at the times of interviews. This group only provided input to the technology concept.

Independent of prior experiences with the buses, the interviewees **expected the technology to be environmental** *("finally something in the right direction")*, with a focus on local air quality. This expectation increased acceptance, although some interviewees questioned climate protection potential, due to the unclear origin of the electricity. As long as

- electricity used for electrolysis was renewable
- hydrogen was a by-product of chlorine-alkali-electrolyses that would not be used otherwise
- input and output products were only water and energy

A majority of interviewees stated that only sustainably generated electricity (excluding nuclear power) was reasonable to justify implementation of hydrogen technologies in transport

people kept their positive attitude towards **hydrogen as a fuel**. A majority of interviewees focussing on electricity as an input factor to hydrogen production discussed acceptability of hydrogen from other than renewable sources. They stated that only sustainably generated electricity (excluding nuclear power) was reasonable to justify implementation of hydrogen technologies in transport[14]. A few citizens argued that a broad implementation of hydrogen into transport would require other than renewable sources for electricity. The sensitivity of electricity related topics seemed to be regionally influenced as

- in some regions people assumed the use of renewable electricity for hydrogen production,

14 This is entirely consistent in the report of interviews with critics and sceptics (CHIC task 3.5.2, deliverable 3.8).

- others pointed to the high regional share of coal and nuclear power plants,
- others addressed acceptance problems of renewable energies, resulting in destruction of the landscape.

In one of the interview regions, hydrogen was produced from chlorine-alkali-electrolysis leading to an increase in uncertainty with some interviewees. The term "chlorine" was associated with "chemistry", resulting in additional questions on the chemical processes and emissions associated with the production of chlorine. The chemical production plant had been situated in the region for decades, which indicates that awareness of the specific activities of the plant was low (in the sample).

Critical questions in regard to the technology concept can be summarized as being origin of the energy, chlorine and energy efficiency of the system. Single interviewees addressed scarcity of water to be used to produce hydrogen via water electrolysis.

Throughout all interview regions passengers noticed changes in driving behaviour, but a significant amount of interviewees stated that they did not notice any difference.

The evaluation of the **FCH bus performance** focused on the bus characteristics, as the general public did not report on any significant outages or decrease in quality of service due to the (un)reliability of the bus technology. Throughout all interview regions passengers noticed changes in **driving behaviour**, but a significant amount of interviewees stated that they did not notice any difference. The interviewees in two regions described driving experiences as *"smooth driving"*, "*as if no fuel was needed*" and *"as if the bus driver coasted"*. The lack of abrupt movements was perceived as being more comfortable to the passengers.

The **noise level** was addressed by interviewees throughout the regions. A majority positively evaluated the FCH buses as quiet in regard to interior and exterior sounds. A few interviewees reported on being disappointed on the noise level experienced, as they still noticed a certain noise level or even an annoying whistling sound.

Differences in vehicle design increased awareness of the buses and resulted in more animated and emotional discussions even with citizens who hadn't been on the buses yet.

The evaluation of **visual aspects** of the FCH buses compared to conventional buses depended upon the individual vehicle design. In one interview region, the new design significantly differed from the conventional appearance. The discussion in this region was significantly more animated than in others. Even interviewees not having been on the bus seemed to be touched by the design

and discussed it as animatedly as passengers. The *"big"* bus was associated with being *"futuristic*" and words used to describe it all related to aviation (*"our U.F.O.", "Next time we will fly to the moon...", "...flying away"*).

Exterior design was also discussed in other regions. Some interviewees reported that the FCH buses were higher than conventional buses, perceiving them as massive. Others stated that the identifying feature of the former hydrogen bus generation, a steam cloud at the top of the bus, was missing. Selected interviewees recognized the buses due to their colouring, and reported on dripping water from the tail pipe. All these characteristics of exterior design were reported rather neutrally without any noticeable implications on the acceptance process.

Some **characteristics of the FCH buses unrelated to the drivetrain or fuel concept** had been noticed by the interviewees and were addressed in the interviews:

- differences in seating: more comfortable seats, new formation of the seats, fewer seats
- differences in the design of the drivers place/ cabin
- different odours

6.3.4. "If it were too expensive, nobody would go for it" – cost discussion and awareness

Interviewees expect the technology to be expensive in the beginning. This expectation is explained by higher cost of any innovation.

The majority of interviewees assumed that the introduction of FCH buses into public transport would result in high cost. It was expected that investment as well as operational cost were considerably higher in the short run compared to conventional bus technologies. This view was not based upon any real knowledge about the cost, but rather an expectation that innovations were always costly. The cost discussion did not influence the acceptance level at the time of the interviews. Explanations could be

- **Lack of knowledge about the true technology cost:** none of the interviewees knew the project or technology cost at the time of the interviews. Even if they had known, they might not be able to relate it to the overall cost of public transport, as these numbers were not known to them either. A few interviewees questioned whether there would be any higher cost related to the operation of FCH buses, as the cost of water and electricity was estimated as being reasonable.

- **Expectation of cost-effectiveness:** at least in the long run, people expect cost to absolutely decrease due to serial production or relatively decrease due to higher diesel fuel cost. In particular the long-run cost perspective was assumed to be a major motivation factor (as well as the environmental benefits) for the public transport authorities to participate in the project.

- **No personal cost impact:** in all of the interview regions no direct cost implications were noticeable to the citizens at the times of the interviews.

The cost discussion could become more relevant to the acceptance process in the future, especially if ticket prices were to be increased or public funding be taken from other departments and activities of interest to the general public (competitive use of public money). The citizens directly addressed an increase in price in the context of the ongoing political and economic situation in the regions or in Europe. One citizen directly asked the question that would have to be answered as soon as considerable numbers of hydrogen buses would be introduced into public transport i.e. "Who will pay for it?"

The **willingness-to-pay** differed from region to region, at a rather low overall level. Some of the interviewees clearly stated that they personally were not willing to accept an increase in ticket prices, others referred to "people in society" who might oppose it as they

Even the interviewees who were willing to pay more considered a "general, global and potential" environmental benefit of the technology as insufficient rationale for the long term acceptance of higher cost and expected additional values.

were not able to afford higher cost of public transport. Some interviewees even estimated indirect cost to the public by using tax money for funding hydrogen technologies in public transport as potentially risky in regions with increasing competition between the departments and political goals. Others argued that reasons for willingness-to-pay would be the environmental benefit resulting from the use of FCH buses in public transport, thereby justifying a redistribution of public money from other sources as e.g. the military budget. In two of the interview regions citizens asked who else would do it if not them, as they perceived themselves privileged compared to other countries and regions in Europe. They seemed to feel like pioneers supporting the development of hydrogen technologies for transport. But even the interviewees who were willing to pay more considered a "general, global and potential" environmental benefit of the technology as insufficient rationale for the long term acceptance of higher cost. They expected additional value, e.g. improved local air quality or a noticeable quality increase in public transport services.

The interviewees in the sample seemed to evaluate technology potential as citizens and technology performance as passengers.

The interviewees in the sample seemed to evaluate technology potential as citizens and technology performance as passengers. It is important to understand that people in the general public were not only "potential (future) users and customers" but reflected on the technology and the project activities from a citizens' perspective, i.e. they represented societal needs and values.

6.3.5. "It is good to know that we are not everybody's crash test dummy" – safety discussion and concerns

Safety issues seemed to be of minor priority to the interviewees at the time of the interviews, and did not seem to negatively influence the acceptance process. This attitude might be explained by

- **Level of trust:** Many interviewees stated to not have any safety concerns in regard to the FCH buses or the HRS station. The lack of concern seemed to originate from trust rather from a considered opinion. They stated that experts and "the system" would minimize risk, and the implementation of new technologies required safe operation.
- **Lack of expertise:** Many interviewees weren't able to imagine safety risks, as they only had a limited understanding of hydrogen and hydrogen technologies. In some of the interviews it wasn't even clear to the interviewer, if interviewees knew that hydrogen was a gaseous fuel.
- **Experiences with other technologies:** Some interviewees evaluated potential safety risks in relation to risks of other fuels and compared handling with the broad utilization of gases in transport (CNG), camping equipment or heating systems in private housings.
- **General attitude towards risks:** Last but not least, interviewees pointed to the fact, that no technology was risk-free.

The discussion on safety issues revealed that evaluations and attitudes did not result from a profound understanding of the topic. It rather reflected an existing trust in authorities (technology system/ suppliers, regulations).

Although a majority of interviewees seemed to be free of safety concerns at the time of the interviews, it is recommended that the role of safety not be underestimated in terms of the acceptance of the implementation process. A few interviewees addressed safety concerns in the interviews, so there were concerns that will have to be addressed by the project and the stakeholders. But more importantly: the discussion on safety issues revealed that evaluations and attitudes did not result from a profound understanding of the topic. It rather reflected an existing trust in authorities (technology system/ suppliers, regulations). One interviewee stated at the end of the interview: *"It is good to know that we are not everybody's crash test dummies!"*, another commented on the list with the regional project partners *"good to know that earning money is not the only motivation"* – The information, that FCH bus demonstration activities were also

implemented in several other European regions and included a broad range of partners from different branches (enterprises, public authorities, research institutes, environmental organization etc.) seemed to calm these interviewees although they had said they had no safety concerns previously. Trust can erode with time as experiences from the food sector or the banking sector have shown in the past years, therefore considering level of trust and safety issues as a factor influencing acceptance is reasonable.

6.4. Preliminary conclusions

The project initiative was clearly supported by the citizens. They appreciated that "finally somebody is taking action for the environment". The awareness about the initiative as well as about the technology potential was generally low, although the FCH buses had been noticed.

The basic findings on the acceptance levels of the demonstration activities and technologies can be assumed to be valid for all regions, and only marginally differ between the regions. The only exception related to the acceptance of the FCH buses as carriage, being generally positive in all regions, but significantly varied in value between the regions (from tolerating to supportive/ excitement).

Passengers and citizens clearly stated that the **priority role of public transport services was expected to remain securing quality of public transport**. As several challenges to the local or regional public transport were already experienced or envisaged *(increase in demand and resulting shortages, tardiness, perceived safety issues with other passengers or in the infrastructures for public transport, transport service in suburban or remote areas)*, any activities others than the core activities did not seem to be of particular interest to the interviewees.

In the best case, people appreciated potential future environmental benefits of the use of FCH buses in public transport and the noble goals of the project initiative. Changes to the bus technology seemed to be generally less evident to the interviewees than changes to processes and services, directly impacting passengers. Thus changes to the bus technology resulting in reduced quality of bus service can be assumed to decrease acceptance significantly. In this context, the potential influence of the low awareness and information levels on the acceptance process could not be definitely evaluated in this study. First conclusions were drawn from the experimental situation in the interviews, empowering interviewees to form an opinion by providing background information on the technology concept and the project initiative. Many interviewees got interested and excited, a few remained indifferent and kept on focusing on the challenges to the quality of public services.

In summary it can be stated that the acceptance process in the general public is influenced by information level, perception of environmental benefits, (awareness of) costs and positive or negative views of project participants or other publicly funded projects (trust in actors, image of actors).

7. Discussion and conclusions

The analysis of the acceptance process of the FCH bus drivers, regional stakeholders and citizens considered for the first time in the known research the acceptance experience during the implementation process of FCH technologies into public transport systems: In line with the **characteristics approach** to acceptance people decide upon a "bundle of characteristics" when deciding for or against a product (see chapter 3.3.2.) The "bundle of characteristics" presented to the bus drivers, the stakeholders and the general public in the CHIC project comprised the project idea, different technology concepts, technology performance and project implementation. Although project implementation differed amongst the regions, general patterns of acceptance could be identified. Nevertheless, the results of the CHIC research on social acceptance are unique and except in their most general sense not transferable to other projects or technologies, as the "bundle of characteristics" changes with technology system, region, project and time.

Important conclusions that might be valuable to people committing to FCH and hydrogen energy projects in the future will be addressed in this chapter. They have to be interpreted as the researchers' opinions about several aspects of the acceptance process that should be considered continuously when deciding on technology concepts and project designs.

7.1. Understanding the acceptance process

Understanding the acceptance process is key to successfully embedding innovations into the societal and regional context and to make use of the technology potential.

Knowing the level of awareness and acceptance among the various actors is important to estimate the current need for information or awareness activities. Understanding the acceptance process is key to successfully embedding innovations into the societal and regional context and to make use of the technology potential. The process of introducing innovative fuel cell and hydrogen technologies into society faces similar challenges as those experienced during change management in organizations: The technology might perform well, but if its introduction and system embedding does not consider organizational or regional structures, processes and/ or values, it risks failing.

7.1.1. The need for acceptance in the transition phase

The transition phase might become the bottleneck for FCH technologies as people will have to choose to buy or use these technologies in a market situation that offers alternatives to them.

The transition phase of FCH technologies and hydrogen energy systems is the time span from single demonstration activities to market penetration (increased demonstration activities and market introduction). The acceptance of fuel cell and hydrogen technologies in the transition phase will be crucial to its wide-spread implementation. People will have to choose to buy or use these technologies in a market situation that offers alternatives to them (first users). The transition phase might thus become a bottleneck and challenge marketing as long as the FCH technologies do not perform comparably or better to the known product. The role of acceptance is expected to be different for the transition phase than in the market phase of hydrogen technologies.

The question is: What kind of acceptance is needed in the transition phase?

Acceptance in the transition phase requires a highly supportive acceptance of all people involved in the process.

The transition phase is expected to be characterized by an increase in technology maturity and infrastructure activities, a decrease in cost, and the need to define business models and operational concepts. Acceptance in the transition phase requires a highly supportive acceptance of all people involved in the process (industrial and regional stakeholders, general public), as they will have to buy (at a premium price), test and optimize technologies, develop strategies and collaborate in order to bring fuel cell and hydrogen transport to market.

Supportive acceptance requires adequate structures and processes, as well as support to stakeholders who are important to the process but for one reason or another are not willing or able to participate (taking risk or cost and effort). It is essential to understand that the development and implementation of FCH technologies in the transition phase depends upon a concerted collaboration of key stakeholders, in order to achieve the momentum needed to initiate changes in several sectors of economy and society.

It has been shown in the CHIC research on acceptance that the **supportive acceptance of stakeholders is most likely to be achieved through enthusiastic people.** These people are willing to do extra work, to spend money and time, and to

provide valuable feedback to the process. Enthusiastic people are motivated by some aspect(s) of the technology or the project. Motivation can also erode with time, as seen in the CHIC project, and has to be monitored and managed in order to be maintained.

Reasons for motivation are very different amongst the stakeholders, thus general recommendations cannot be provided. The individual factors for motivation have to be identified at a stakeholder or regional level.

The general public has to be seen as citizens influencing politics and evaluating the acceptability of public funding on the one side, and as consumers investing private money on the other side. Within this group, it is the story that needs to be sold first before selling the product.

The need for **acceptance in the general public** is expected to change within the transition phase from societal acceptance to individual (consumer) acceptance. The general public can be seen as citizens influencing politics and evaluating the acceptability of public funding on the one side, and as consumers investing private money on the other side. *Citizens' acceptance* is important at the beginning of the transition phase, as it influences decisions in politics and at CEO level of companies investing in a technology without short-term return on investments. *Consumers' acceptance* will become increasingly important towards the end of the transition phase, when decisions on investments become private.

The CHIC research on social acceptance revealed the technology concept and the vision of "green transport" as highly supported by the general public. Details on the technology itself did not seem to be of interest to a majority of citizens at the time of interviews. They felt alienated by too much information on issues not directly related to their daily lives. It is important to understand the need for information in this group, which is rather a need to understand strategies and stakeholder motivation to invest in this technology. *In summary: Within this group, it is the story that needs to be sold first before selling the product.*

7.1.2. The importance of personal involvement

An increase in distance from everyday experience with the technology resulted in a decrease in emotional attitudes and an increase in more rational views.

The level of personal involvement in the project was impressively reflected in the way the interviewees talked about the issues. An increase in distance from everyday experience with the technology resulted in a decrease in emotional attitudes and an increase in more rational views. This effect has to be seen as unfavorable in situations where the technology potentials have to be "sold", and as favorable in situations addressing (temporary) problems in the implementation process. Conclusions about the understanding of the acceptance process are that

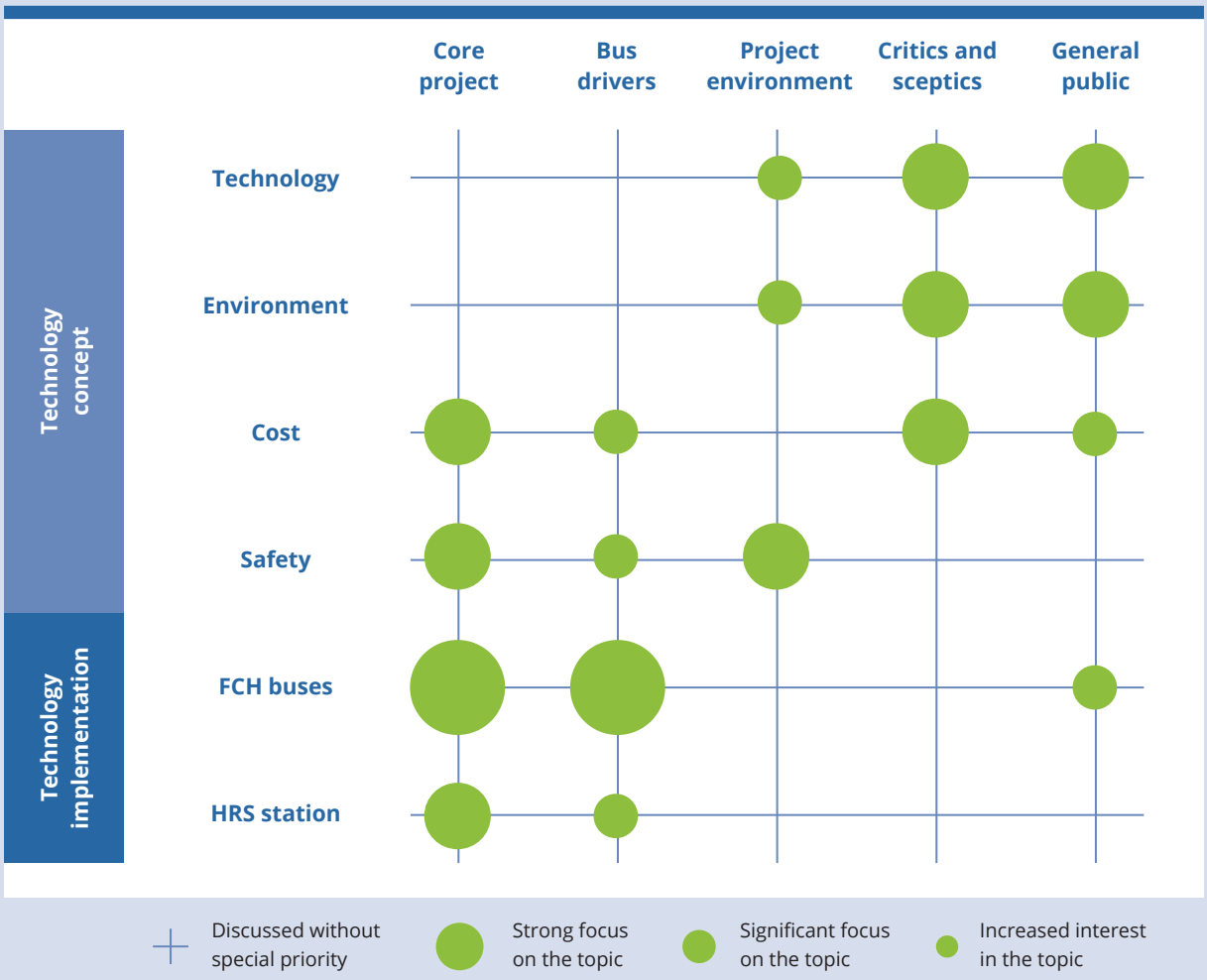
- **the acceptance of problems in the implementation process is higher** the less people are directly involved and thus personally effected in their daily lives. It is mandatory that people less involved in the project and the processes are kept updated on the progress, a lack of information erodes acceptance significantly.

- **the acceptance of the technology and awareness of its potential** for improving daily work life and health is higher the more people are directly involved and thus personally effected in their daily lives. Global issues (climate protection, security of energy supply) become more (the only) important arguments influencing the acceptance process for people less directly involved in the projects and the implementation process.

- **FCH buses are perceived as "only an option" amongst others** as long as climate protection or security of supply is perceived as the only benefit of the technology, resulting in a more critical view of cost and reliability. An unemotional attitude risks evaluating FCH buses as a replaceable technology concept.

The personal nature of various actors' involvement is not only reflected by the way people were addressing issues but also by the choice of issues to be focused on. The interview guidelines provided a general framework ensuring that all topics were addressed but left it to the interviewees to decide upon the key aspects (Figure 5).

Figure 5: Comparison of the CHIC interviewees interests



The interviewees most involved in the demonstration activities did not seem to focus on or question the suitability of the technology concept or the environmental benefit (any more).

The interviewees most involved in the demonstration activities (core project, bus drivers) did not seem to focus on or question the suitability of the technology concept or the environmental benefit (any more). The less involved people were in the process, the more important these issues became in the interviews. The evaluation of technology and project performance was of utmost interest to people directly involved, and only barely addressed by the actors in the project environment and with critics and sceptics.

The question is: Who profits most from FCH technologies?

The CHIC project was all about demonstrating fuel cell and hydrogen technologies in public transport. Considering the results from this analysis on the acceptance process, the decision to choose **public transport fleets** as area of application seems to be wise, as it reflects a most favorable market situation. Three different roles and levels of involvement are represented within one organization as shown in Table 15.

Table 15: Public transport authorities representing favorable market situation

Perspective \ Interest	Technology potential	Technology characteristics	Technology performance
... employer (user perspective)	Image	Improve work environment	Secure quality of service
... public authority (political perspective)	Secure goals of CO_2 free transport, image	Reduce local impacts (noise, air quality)	
... entrepreneur (economic perspective)	Secure fuel supply at reasonable cost, image	Improve quality of service	Reduce cost, secure operation

An equal balance of interest is important to maintain and increase acceptance and has to be supported in regions where these three perspectives are legally or organizationally shared between different departments, companies or organizations.

All three market perspectives involved in public transport should be considered in the design and implementation processes of FCH bus demonstration projects. An equal balance of interest is important to maintain and increase acceptance and has to be supported in regions where these three perspectives are legally or organizationally shared between different departments, companies or organizations. Any (perceived) disadvantage to individual stakeholders due to unevenly distributed costs and benefits negatively influences the acceptance process.

It is reasonable to expect that acceptance will be lower among potential customers who have not considered the three perspectives in their decision, either because they

- do not emphasize the environmental perspective (e.g. private fleets)
- do not emphasize the long-term economic perspective or the quality of work environment (e.g. private individual users)

7.1.3. The role of added value

The transition phase for hydrogen and fuel cell technologies is expected to happen within the next decade. As many European countries and companies face severe economic and social challenges, it will be difficult to introduce hydrogen and fuel cell technologies on a broad-scale to the market, where early adopters can expect higher cost and less comfortable infrastructure or lower reliability (teething problems) for early adopters.

Changing a running system, and switching to a new technology when competitive and reliable alternatives are in place, will require more than "just" environmental benefit and energy efficiency – it requires a greater added-value to the early adopters (region and/or organization).

The social acceptance needed in the transition phase of a new technology is a highly **supportive acceptance**: people will either have to actively use it, adapt their behaviour, pay additional cost or take the risk of investing into this new technology. Possible motivation factors to make these changes are manifold e.g.

- people want the product, as they see an additional benefit to themselves, they are convinced.
- people want the image, that comes along with the product and accept the product: they feel responsible.
- people are "externally motivated" to use the product: they accept disadvantages through trade-off.

It is not always the absolute cost that seems to be relevant to the acceptance process, but the perceived added value that offsets the additional cost.

The analysis of expectations and experiences of bus drivers, stakeholders, and the general public revealed a set of regional challenges to be tackled. The implementation of hydrogen technologies into public was not considered the most pressing challenge in the regions. As long as the concrete regional or personal benefits remain unclear to the project environment and the actors responsible for supporting the implementation process, "value for money" will be questioned.

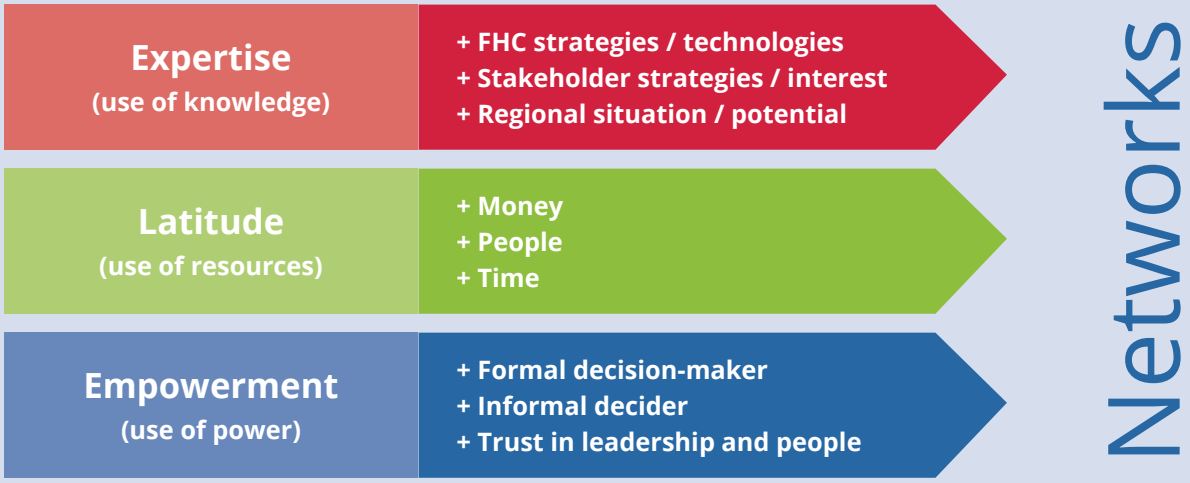
"Value for money" might be a promising concept to increase motivation and acceptance of higher cost or the need to change behaviour, as interviewees in the CHIC research stated. It is not always the absolute cost that seems to be relevant to the acceptance process, but the perceived added value that offsets the additional cost. For the transition phase it could be helpful to find added value others than the ones related to the technology concept. For example, improved bus services related to hydrogen buses (connections, schedules, fast lanes), more comfortable or appealing interior and exterior design of the buses (including seating) and other improvements will help to increase acceptance of higher cost.

It will also be necessary to show novelty, thus it might be helpful to not "hide" the technologies but to aggressively promote them (e.g. increase recognition value and uniqueness). Understanding the cost discussion as a "value for money" discussion shows that focussing on only environmental benefits and climate protection might not be sufficient to convince critics and sceptics to support FCH technologies. A variety of other potential and cheaper technologies or concepts were seen as being suitable for achieving reduced emissions on a global and a local level and improving the carbon footprint of an individual, a sector, or a nation.

7.1.4. The advantages of networks

It was shown in the stakeholders' interviews that the successful demonstration of FCH technologies in public transport required expertise, latitude and empowerment of people (Figure 6).

Figure 6: The role of networks in the acceptance process



As soon as people

- have access to the necessary information and knowledge (expertise)
- have the resources to develop and implement ideas (latitude), and
- are legitimated to change a situation (empowerment)

they are likely to succeed in realizing their ideas. The group of stakeholders interviewed in the CHIC research included a few strong personalities or small teams, who seemed to be close to fulfilling all three competencies, but this has to be considered as an exception. Networks were seen as being of general importance to make use of the competencies of the different stakeholders thereby enabling constructive cooperation. The advantage of networks was seen in sharing knowledge, work and responsibility/

The advantage of networks was seen in sharing knowledge, work and responsibility/risk.

risk. Networks that grew too big were considered to rather hinder the processes as the coordinating effort increased, involvement and personal commitment decreased, and interests were diversified.

The situation of the CHIC project was challenging to the stakeholders in the regions and in the project, as a "new" network was set up to implement the project, providing expertise and additional resources as well as self-interests. The consolidation of the hydrogen project network and the regional networks (most of them being involved in initiating the project, and with regional empowerment) seemed to be lacking or incomplete, and stakeholders in some of the interview regions addressed a lack of information and interaction with the project in their interviews. Only regions with a local network coordinator being responsible for promoting regional hydrogen strategies seemed to manage the networks well. The relevance of networks for the implementation process was seen in the support they provided to the individual stakeholders. In a situation that requires changes to existing structures and processes without a guarantee of success, resulting uncertainty can hinder efficient implementation. The necessary certainty was reported to be provided by networking structures that remained unchanged and supported activities by providing additional resources and expertise. It was also stated that existing relationships of trust between network partners eased the initiation phase, as not only was the concept more readily accepted but the idea was directly connected to the network activities. In some cases however, some criticism was experienced due to negative views of the network behind the idea.

In summary it can be stated, that existing regional network structures were important to initiate the project, and to ease the implementation process by pooling risks and sharing resources. They increased acceptance as they reduced work load and stress. In some case they hindered the acceptance in situations where the reputation or history of the network didn't convince critics or sceptics.

7.1.5. The human factor

The "efficiency degradation of a vision" does not occur at a defined rate but is strongly dependent upon the people responsible for realizing the idea.

The potential of an idea is limited by a technology concept, whereas the potential of a technology concept itself is limited by the implementation process of this concept. This quasi **efficiency degradation of a vision** does not occur at a defined rate but is strongly dependent upon the people responsible for realizing the idea. Their ability to overcome challenges, identify opportunities as well as their willingness to take responsibility and share risk defines the achievement of objectives.

Important characteristics of people advancing the innovation and implementation process seemed to be

- willingness to take responsibility and ability to tackle problems
- trust in employees and providing an encouraging environment
- searching for (uncommon or risky) solutions instead of safeguarding
- being creative and communicative
- acting independently, and enduring criticisms and set-backs

The better the stakeholders were integrated into a supporting network, the more easily they seemed to operate; the more they operated on their own, the more difficult and time-consuming necessary changes appeared to them. If the working environment was not prepared to support change, and if no network made up for lacking organizational or project structures and processes, the person responsible for the activities risked burn-out or changed jobs.

The human factor strongly influenced the acceptance process as most people seemed to be highly motivated by the technology potential and/ or the project initiative/ idea. They were willing to accept a difficult working environment and stressful situations and thus supported the implementation process in the transition phase.

7.2. Managing the acceptance process

7.2.1. Reflecting progress

The daily project work required steady attention and prompt reactions to challenges, occupying people in a manner that left only a little time and leisure to reflect, understand and appreciate project progress.

It has been shown that acceptance is a process requiring reflection from time to time by the actors involved in order to evaluate expectations, progress and performance. The **daily project work required steady attention and prompt reactions** to challenges, occupying people in a manner that left only a little time and leisure to lean back and understand and appreciate project progress. Some interviewees in the stakeholder group spontaneously thanked the interviewers for the reflection process that was initiated by the qualitative interviews. They tended to be more positive after reflecting on the project history, personal motivation and relevance of the activities in the regional and in the broader context. Some stated that project relationships had become more obvious while explaining issues to the interviewer, although they were in possession of no additional input or information on project or technology progress in their own or other CHIC regions. Some of the interviewees even started to develop solutions to problems or think about alternatives to existing strategies and activities during the interview.

The interviews also revealed that people who were involved in the process at the time of the interviews tended to focus on problems rather than on success stories as they were searching for solutions. The interviews with people who were not involved in the processes any more or who reported on former projects and activities appeared more positive and relaxed, as the overall vision and original motivation to participate in the project re-emerged. Challenges and problems were evaluated as less severe; acceptance seemed to be positively influenced with distance (time and involvement).

Last but not least, the need for providing feedback and sharing ideas and experiences was impressively demonstrated by many of the interviewees who came well prepared to the interviews and spontaneously addressed several issues.

In order to **keep motivation and use the broad experience** *and willingness of many project participants and regional stakeholders to support the project, it is suggested reflection processes be integrated into the on-going project process. Reflection processes temporarily reduce personal involvement and allows for a more "rational" and less "emotional" view of challenges and problems (see 7.1.2)*

7.2.2. Manage expectations

Every project and technology framing ("story") that is communicated influences expectations. Every lack of "official story" risks the birth of unofficial stories, made up and communicated by people looking for a story or wanting to influence the process. It was shown in the interviews with the citizens that a perceived lack of communication led to irritations and scepticism.

Expectations that influenced acceptance in the CHIC project were in particular expectations on

- technology potential and characteristics
- technology performance
- project structures and processes (responsibilities, time to react to problems, expenditure of time and costs, etc.)
- frequency and quality of information exchange
- level of personal relevance to the project
- level of personal involvement (change in routines, additional work load)
- reporting needs (internal and to the CHIC project)
- added values (technology, work environment, personal situation)
- feedback from inside and outside the project
- level of support from the CHIC partners (expertise)
- level of support from colleagues and supervisors in the company/ organization (recognition, resources, expertise)

As long as expectations were met or exceeded, acceptance remained unchanged or increased.

As long as expectations were met or exceeded, acceptance remained unchanged or increased (as with the electric drive in the group of bus drivers, or the technology potential in the group of citizens). As soon as expectations were not met, acceptance decreased (as with the reliability of the technology in the group of bus drivers or stakeholders).

Almost all interviewees did distinguish between "project" and "technology" as well as between "performance" and "potential": Disappointment with project processes did not automatically result in a decrease of technology acceptance and vice versa.

It has to be understood that almost all interviewees did distinguish between *"project"* and *"technology"* as well as between *"performance"* and *"potential"*. So disappointment with project processes did not automatically result in a decrease of technology acceptance and vice versa, in the same way as people being disappointed by technology performance did not necessarily question future technology potential. The sample interviewed in this social research on FCH technologies in public transport proved to (still) be quite positive and robust to challenges in the project, but erosions in acceptance due to unfulfilled expectations could already be noticed at the time of interviews.

It is therefore important to manage expectations to avoid further erosions of acceptance and keep people and regions motivated and committed to the project. Managing expectations faces two major challenges:

+ **Overselling versus underselling** – The initial project phase requires highly supportive acceptance of many stakeholders to "get the project running" (expertise/ personal capacities, motivation, time, money). The willingness to commit to the project is best reached by overselling it, i.e. by raising expectations. As soon as the project is on-going, underselling would be the best approach to avoid frustration when expectations are not met. Therefore a conscious and anticipatory balance of overselling and underselling should be pursued.

+ **Expectation conflicts** – It is obvious that different stakeholders have different agendas. Managing expectations therefore must always include balancing expectation conflicts in order to reduce overall frustration.

The results of the CHIC interviews indicate that **managing expectations should be an on-going process** considering

+ **each other's needs:** What requirements are important to the individual and how is the personal situation impacted by the project or the technology? E.g. not being informed on the project and its progress could lead to embarrassing situations for stakeholders or bus drivers confronted with questions from the media or the public.

+ **implicit and explicit expectations:** Not all expectations are explicitly stated right from the beginning, some might be unconscious or evolve with time. E.g. expectations on time spans to fix problems, or on reactions to feedback information.

+ **a transparent and on-time communication strategy to avoid rumours and the formation of unsustainable expectations**: Expectations are managed by the information provided to the actor, or the story developed and communicated to explain motivation and activities. As it was shown in the CHIC interviews, most citizens and many stakeholders are open-minded and positive towards the activities but need more information to feel comfortable in decision making/ positioning. As long as they do not receive sufficient information, they will try to inform themselves, through accessing any kind of information.

It is important to understand that managing expectation is not only necessary with the "outside community" or other regional stakeholders but also within the project actor's organizations and in the project consortium. The colleagues, supervisors or partnering companies do have expectations about technology performance, project progress, activities and results. Knowing these expectations is important to pro-actively manage expectations and provide information to avoid disappointment, frustration and misunderstanding.

7.2.3. Secure information flows

It has been shown, that the level of involvement influences motivation. People who are not part of the daily project work therefore need to be kept involved by a continuous information flow, enabling them to follow project progress and understand challenges. People who are part of the daily project work need an exchange of information to increase decision making and responsibility as these factors were identified in the interviews to be central for personal motivation. This includes:

- **Listening to people:** motivates them as they feel valued, but also provides important input to the project and the processes as useful feedback might assist optimization and support progress.

- **Talking to people** (providing information of project progress, activities and challenges) empowers them and avoids embarrassing situations, especially when they are to provide answers to questions from outside. They might themselves better understand reasons for time lags and short backs.

It was often not a question of "whether" the project or the technology was accepted but "how" the implementation process and project progress was perceived.

It was often not a question of "whether" the project or the technology was accepted but "how" the implementation process and project progress was perceived. As explained in the previous chapters, (positive) expectations of the project and the technology have to be met to secure or increase acceptance. A continuous information flow to provide the necessary information for evaluating expectations and experiences is thus of utmost importance to the involvement of people and strongly influences the acceptance process.

To finish with a bus driver's statement on the question for feedback to the EU as co-funding organization of the project, summarizing the generally positive attitude towards the initiative throughout the interviewees:

"I don't know. I just know that this is a very good project. You have to think about the future. Somebody has to act. It costs a lot of money but this shouldn't be the issue..."